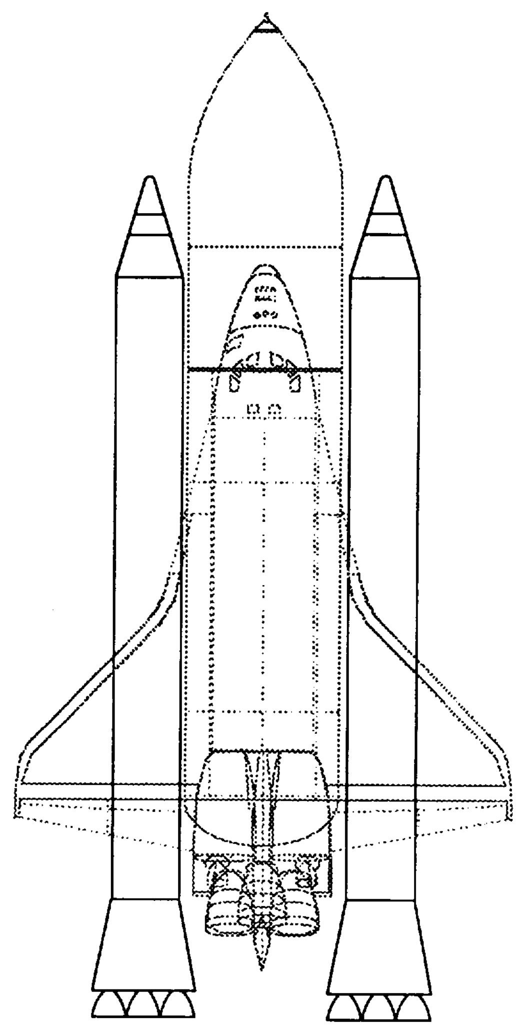
NAS8-37136

March 1989

Appendix E
Pressure-Fed
Booster Test
Bed for the
Liquid Rocket
Booster Study

Liquid Rocket Booster (LRB) for the Space Transportation System (STS) Systems Study



(NASA-CR-183791-App-E) LIQUID ROCKET BOOSTER (LRB) FOR THE SPACE TRANSPORTATION SYSTEM (STS) SYSTEMS STUDY. APPENDIX E: PRESSURE-FED BOOSTER TEST BED FOR THE LIQUID ROCKET BOOSTER STUDY (Martin Marietta

N90-28605

Unclas

G3/20 0251596

MARTIN MARIETTA
MANNED SPACE SYSTEMS

L-004/jer

Pressure-Fed Booster Test Bed for the Liquid Rocket Booster Study

Appendix E

PRESSURE-FED BOOSTER TEST BED

INDEX

PRESSURE-FED BOOSTER TEST BED

INTRODUCTION

This report describes the stress analysis/structural design of the Pressure-Fed Booster Engine Test Bed using the existing F-1 Test Facility Test Stand at Huntsville, Ala. The analysis has been coded and set up for solution on NASTRAN. A separate stress program was established to take the NASTRAN output and perform stress checks on the members. Joint checks and other necessary additional checks were performed by hand. The notes include a brief description of other programs which assist in reproducing and reviewing the NASTRAN results. These programs are included on the accompanying tape.

CRITERIA & LOADING CONDITIONS

The redesign of the test stand members and the stress analysis was performed per the A.I.S.C Code. Loads on the stand consist of the loaded run tanks, wind loads, seismic loads,live loads consisting of snow, ice and live, dead load of the steel, and loaded pressurant bottle.
In combining loads, wind loads and seismic loads were each combined with full live loads. Wind and seismic loads were not combined.
No 1/3 increase in allowables was taken for the environmental loads except at decks 147 and 214 where the increase was used when considering the stay rods, brackets and stay beams.

GENERAL COMMENTS

Wind and Seismic loads were considered from each of the 4 coordinate directions (i.e. N,S,E,W) to give 8 basic conditions. The analysis was run with the pressurant tank mounted at level 125. 1 seismic condition was also run with the tank mounted at levels 169 and 214. No failures were noted with mounting at level 169, but extensive deck failure with mounting at level 214 (The loadsets used are included on the tape, but no detailed results are included in the package).

Decking support beams at levels 147 and 214 are not included in the model. The stress program thus does not reduce strut lengths to the length between support beams (the struts are attached to the beams at intersection points) and gives stress ratios larger than 1 for some of the struts. The affected members were therefore checked by hand.

MARTIN MARIETTA
MICHOUD OPERATIONS

JC DATE 3/30 SUBJECT PFBTS. SHEET ____ OF 2-1

WORK PACKAGE

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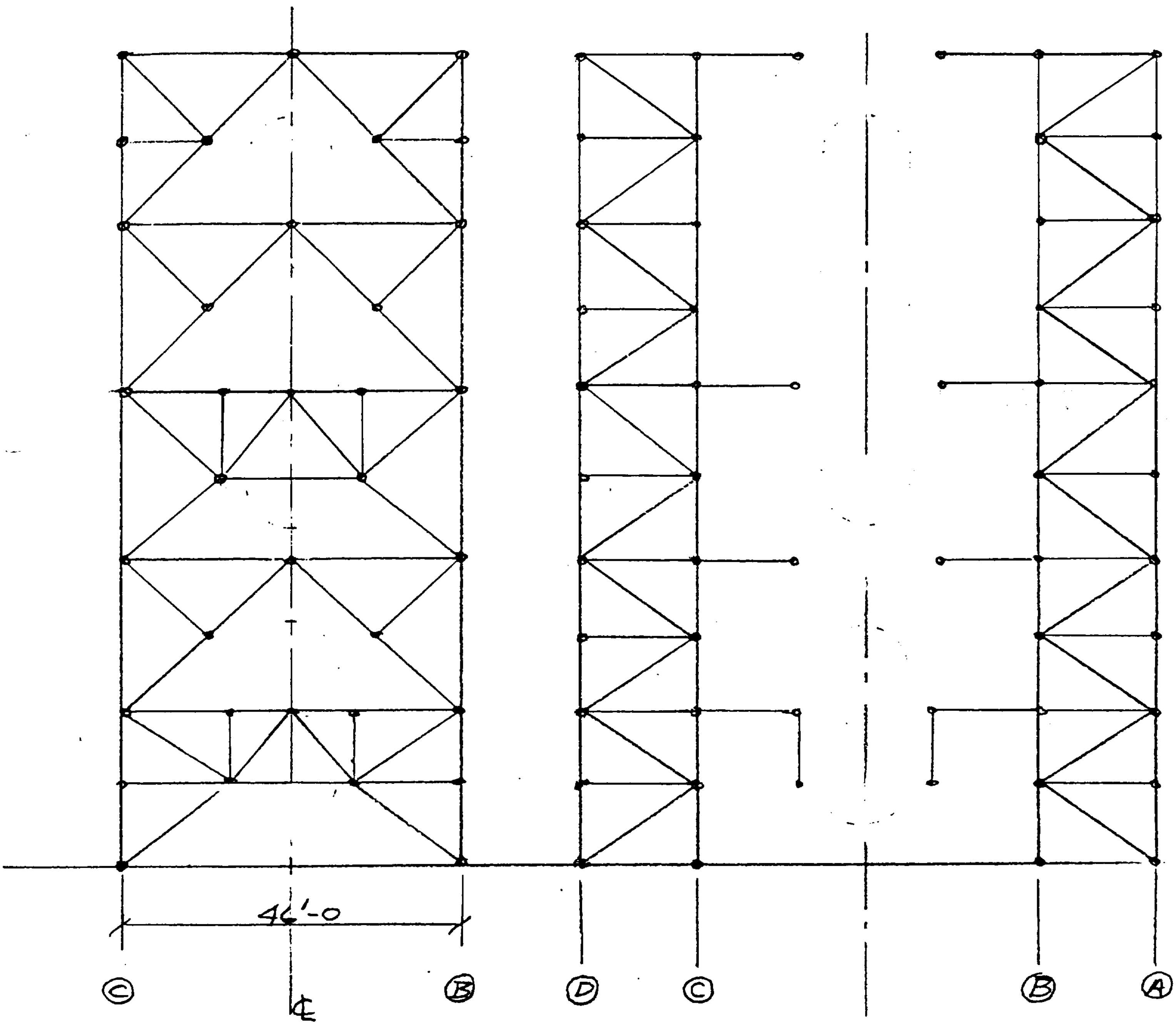
MATH MODEL — MAIN STEEL

THE STAND ORIGINAL GEOMETRY IS BEST OBTAINED BY REFERENCE TO THE ORIGINAL DRG. SET, I.E. R 12070 A SHTS T-S26 THRU T-S34.

SKETCHES OF PARTS OF THE ORIGINAL GEOMETRY WITH THE APPROXIMATE NEW TANK POSITION SUPERIMPOSED ARE GIVEN ON FOLLOWING SHEETS.

MATH MODEL - MAIN STEEL



EAST ELEV @ 1

EAST ELEV @ 2

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MICHOUD OPERATIONS

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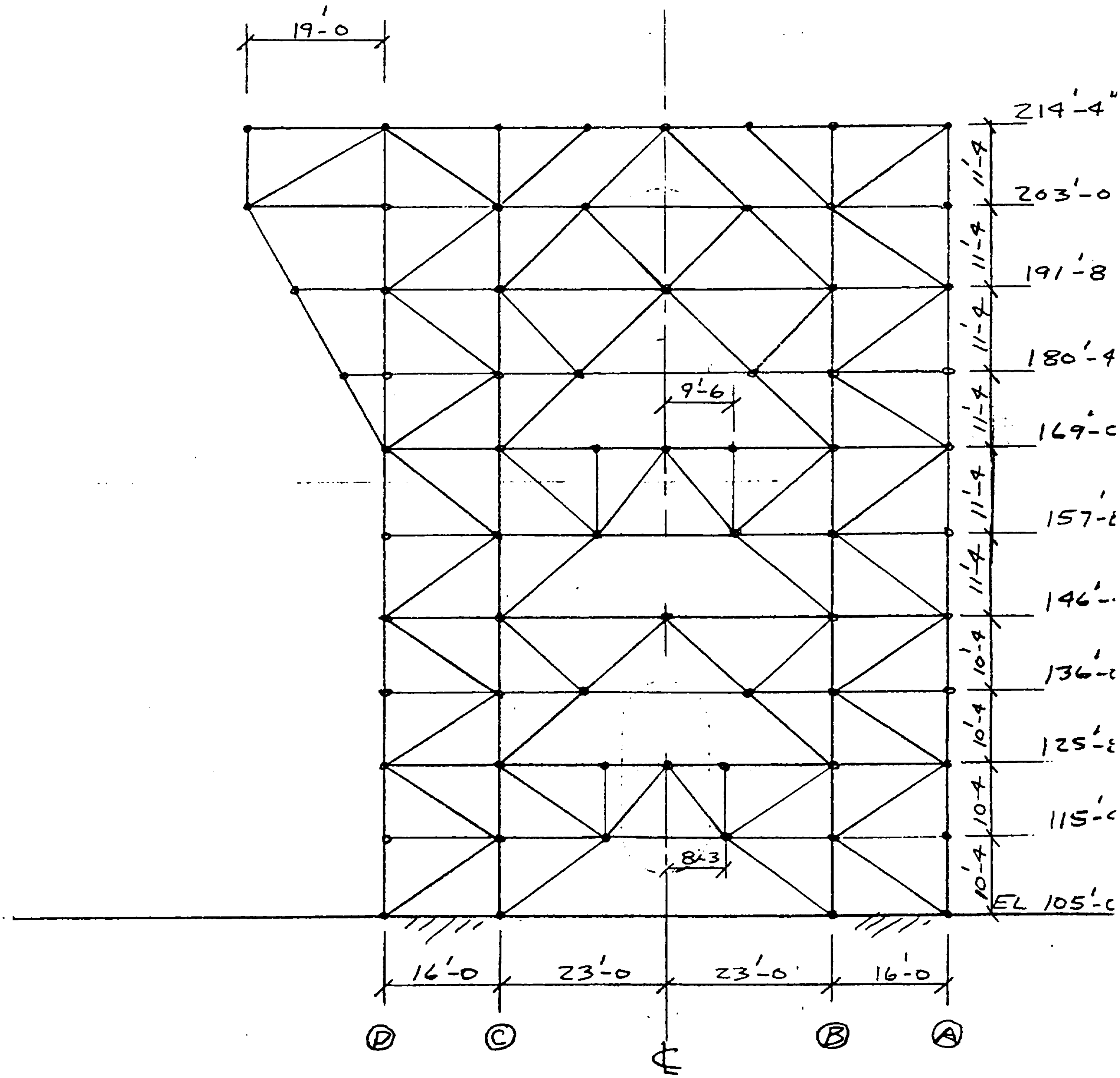
MATH MODEL - CONT'D



EAST ELEV. @ 3

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MICHOUD OPERATIONS

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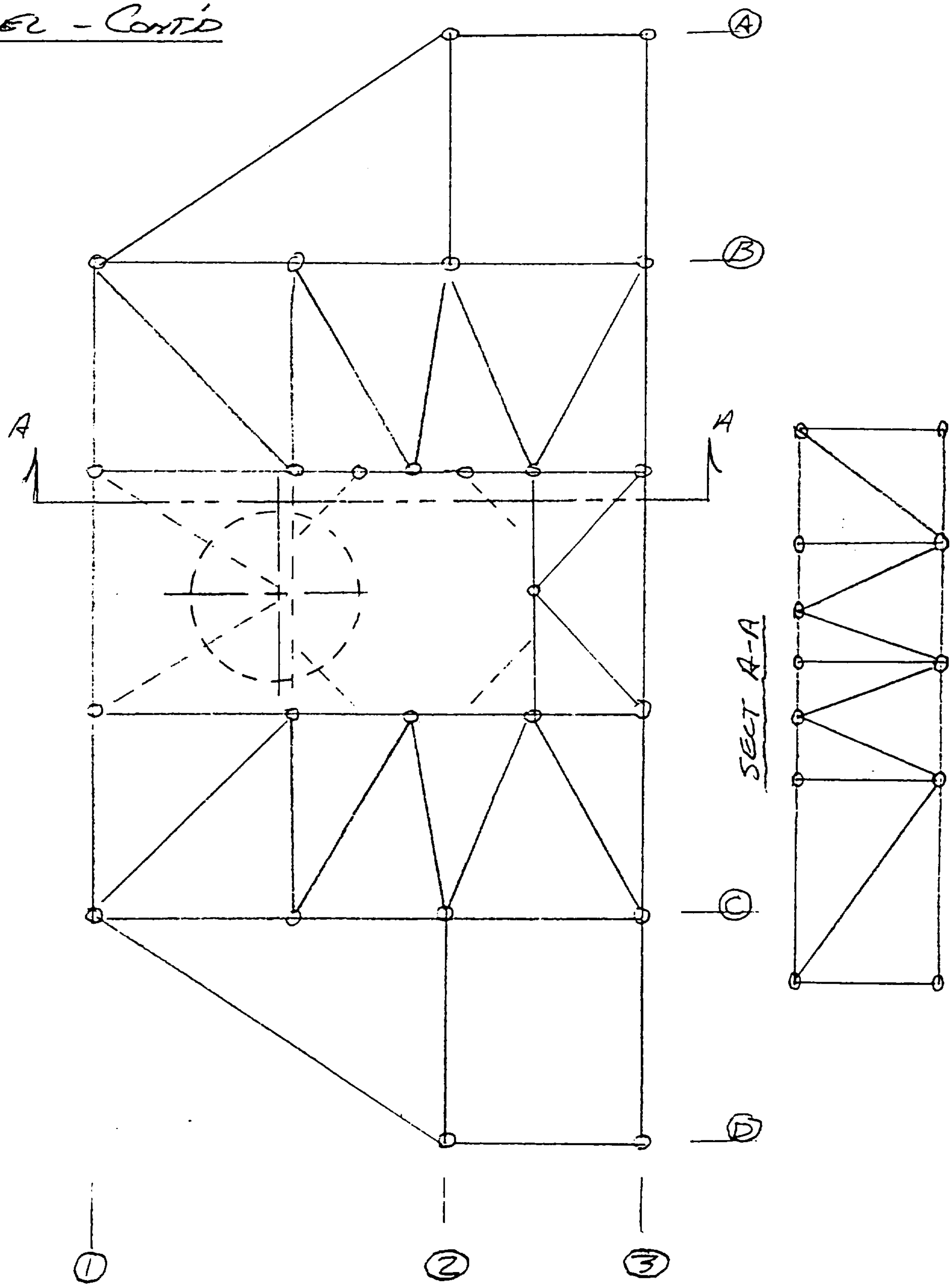
MATH MODEL - CONT'D



ELEV 125'-8

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MICHOUD OPERATIONS

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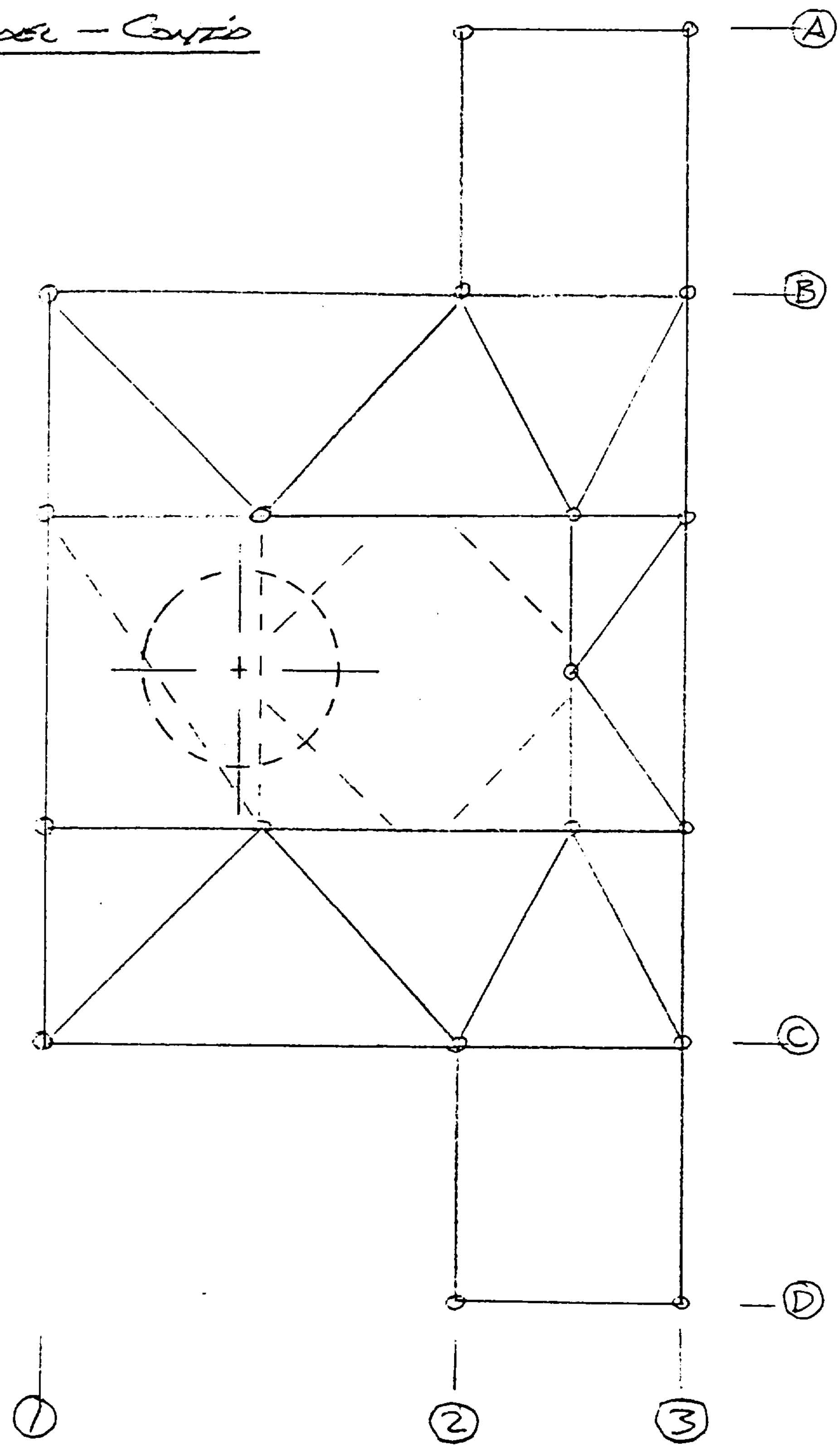
MATH MODEL — CONT'D



ELEV 146'-4

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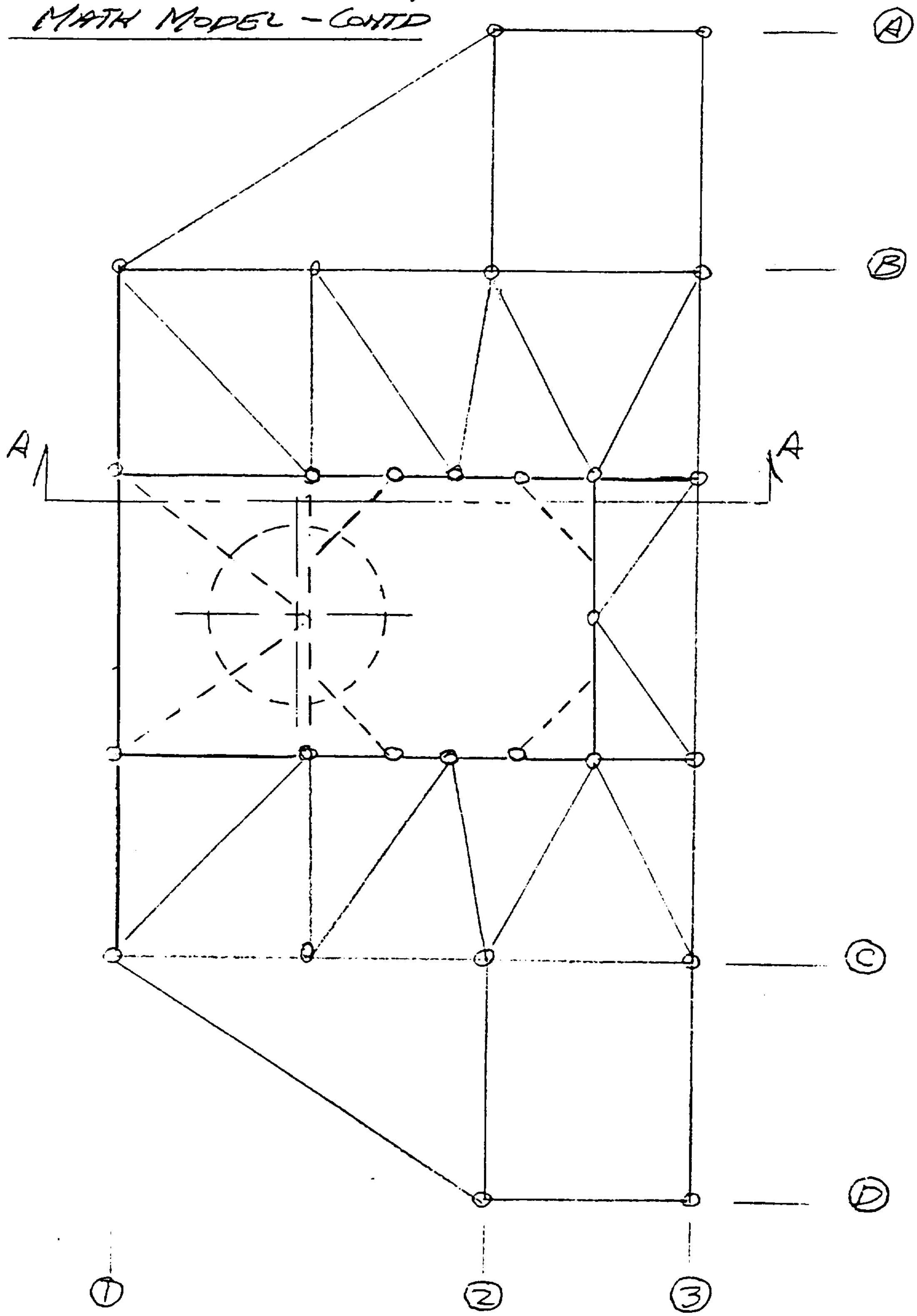
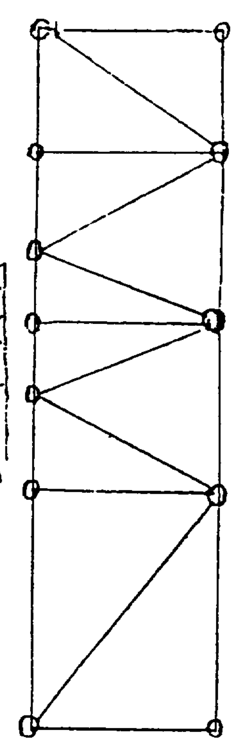
MATH MODEL - CONT'D



ELEV 169'-0

SECT A-A



MARTIN MARIETTA
MICHOUD OPERATIONS

EHP DATE 8/30 SUBJECT PEBTS

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WORK PACKAGE

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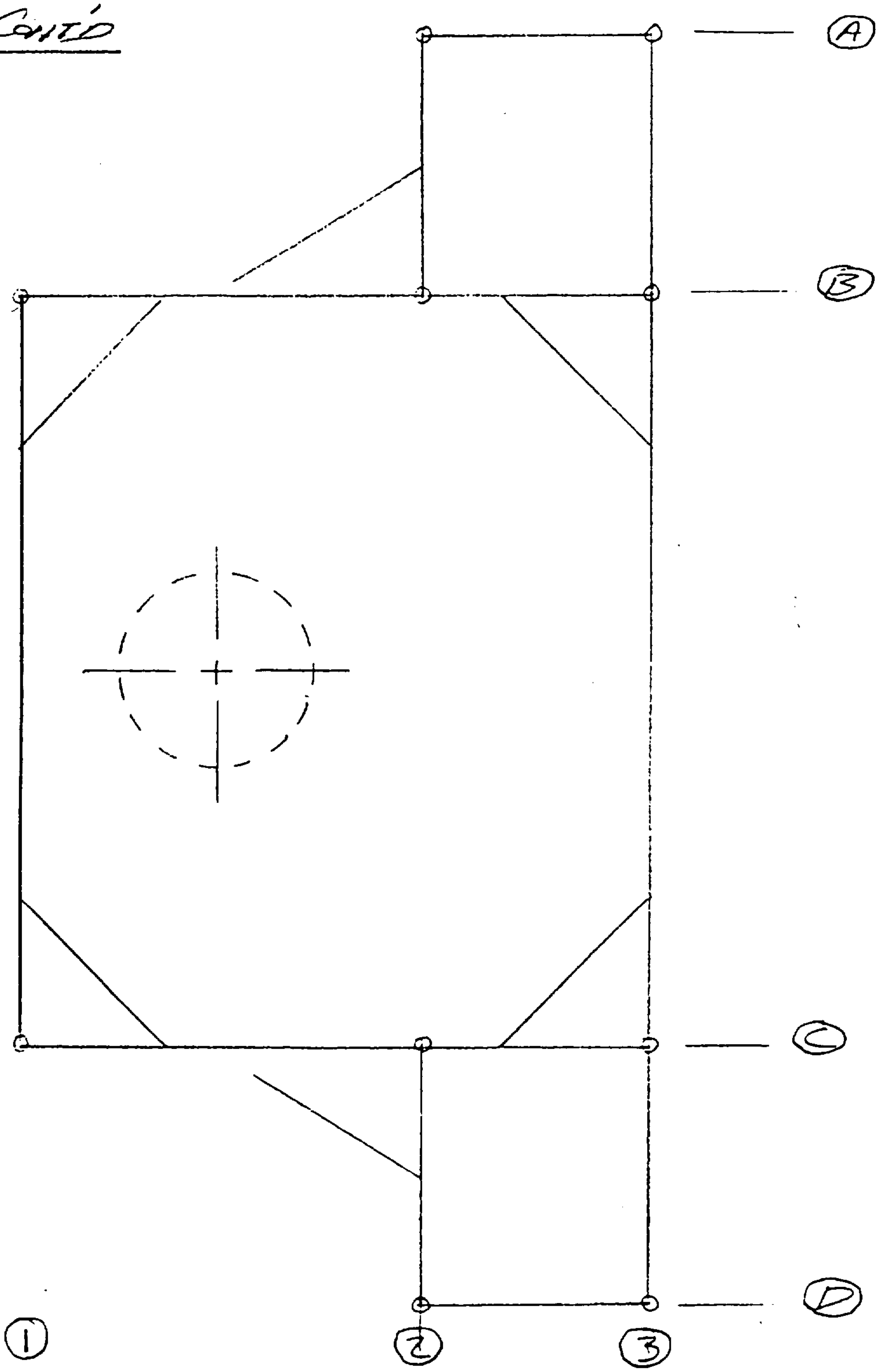
MATH MODEL - CONT'D



ELEV 191'-8

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MARTIN MARIETTA
MICHOUD OPERATIONS

SHEET ______ OF 2-8

EHP DATE 8/30 SUBJECT PFBTS

WORK PACKAGE

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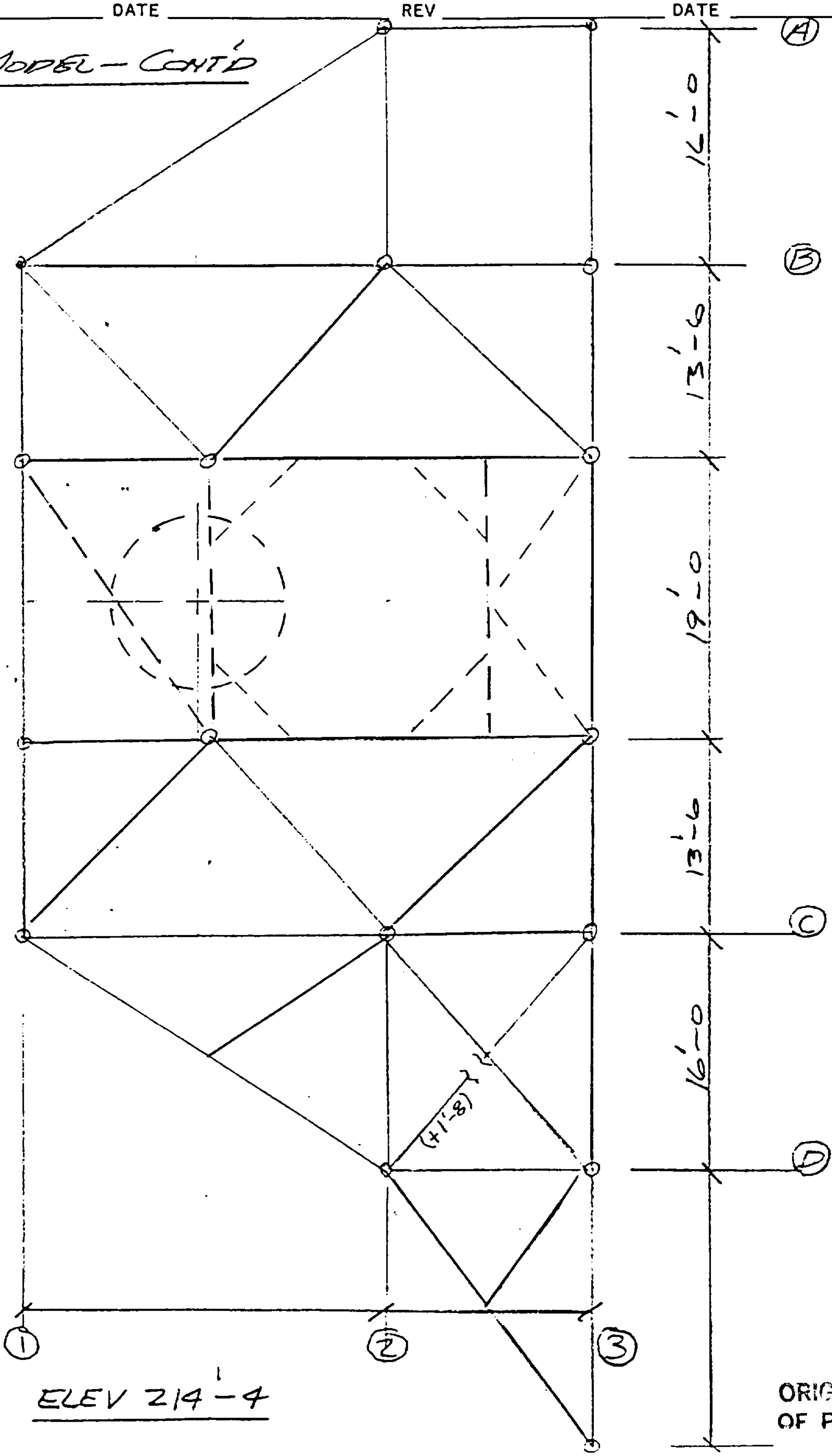
APPROVED ______ DATE ______ REV ______ DATE ______

MATH MODEL – CONT'D



ELEV 214'-4

NEW GEOMETRY

THIS SECTION CONTAINS A SUMMARY OF THE TANK MODIFIED GEOMETRY.

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MICHOUD OPERATIONS

JC DATE 3/30 SUBJECT PFBTS SHEET ____ OF 3-2

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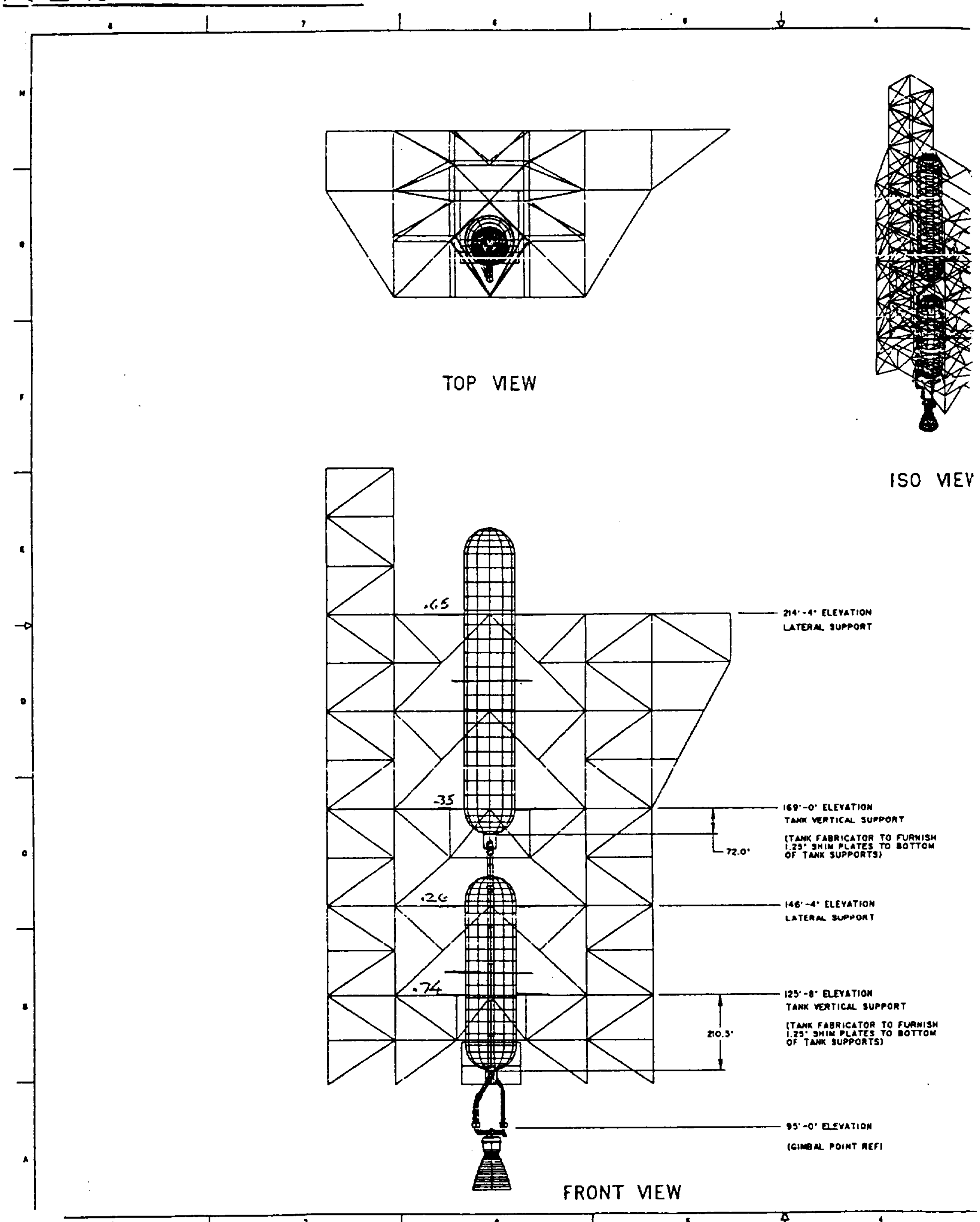
New Geometry



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ARTIN MARIETTA
MICHOUD OPERATIONS

JC DATE 3/30 SUBJECT PFBTS SHEET 3 OF 3

WORK PACKAGE

ROVED DATE

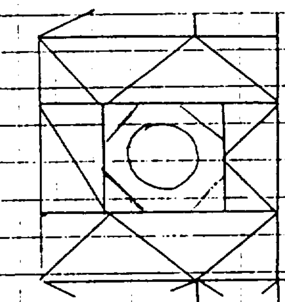
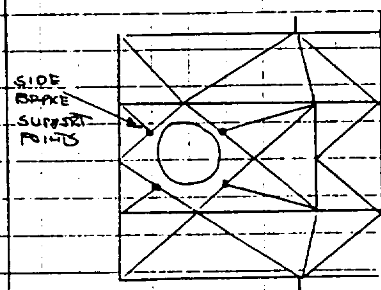
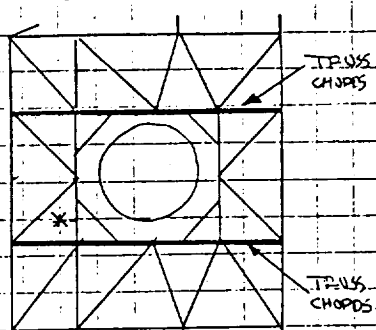
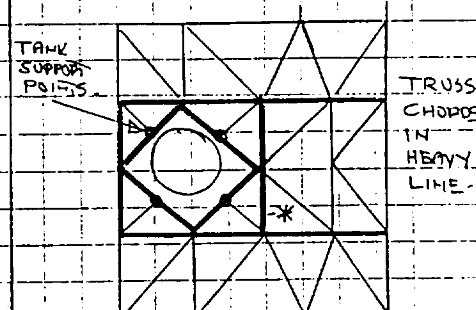
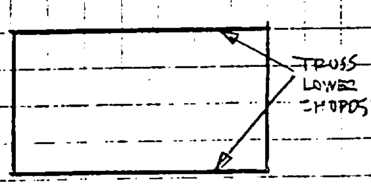
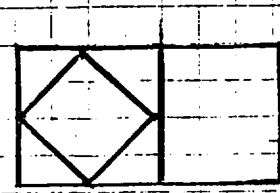
PROVED DATE REV DATE

NEW GEOMETRY

CONFIGURATION ALTERATIONS TO THE STAND ARE IN ESSENCE:

- REMODELLING OF LEVELS 115, 125, 157 & 169 TO PROVIDE NEW TRUSS SYSTEMS FOR TANK SUPPORT IN THE ALTERED POSITION.
- REMODELLING OF DECK LEVELS 147 & 214 TO PROVIDE LATERAL TANK SUPPORT.
- UPSIZING OF VARIOUS WALL MEMBERS WHERE INDICATED.

MAIN ALTERATIONS ARE SUMMARIZED BELOW. REFER TO THE DRAWING SET FOR FULL DETAILS.

ELEV.	ORIGINAL	PROPOSED
214		
169		
	CROSSBEAM MARKED * RELOCATED AS SHOWN.	
157		

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MARTIN MARIETTA
MICHOUD OPERATIONS

JG DATE 3/30 SUBJECT PFBIS SHEET 3 OF 4

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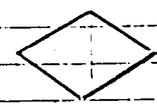
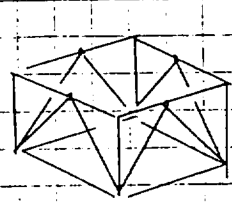
NEW GEOMETRY

SIMILAR ALTERATIONS ARE MADE AT ELEVATIONS 147, 125 & 115 FOR LOWER TANK SUPPORT.

THE ADDED TRUSS MEMBERS  IN PLAN VIEW

ARE  IN ISOMETRIC.

THE ALTERATIONS SHOWN AT ELEVATIONS 214, 169 & 157 ARE THE ALTERATIONS NEED TO SUPPORT THE UPPER TANK. ALTERATIONS FOR LOWER TANK SUPPORT AT ELEVATIONS 147, 125 & 115 ARE SIMILAR.

IN ADDITION TO MEMBERS REPLACED BECAUSE OF CONFIGURATION CHANGES, OTHER MEMBERS IN THE ELEVATIONS & WALLS NEED UPSIZING DUE TO INCREASED LOADS.
MEMBERS AFFECTED ARE LISTED ON FOLLOWING SHEETS.

MARTIN MARIETTA
MICHOUD OPERATIONS

SHEET ___ OF 3-5

JC DATE 3/30 SUBJECT PFBTS

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NEW GEOMETRY - UPSIZED MEMBERS

UPSIZED ELEMENTS (WITHOUT OTHER CONFIGURATION CHANGE) ARE LISTED BELOW.
THE KEYS TO ELEMENT POSITIONS & TYPES ARE GIVEN IN THE APPROPRIATE SECTIONS.

ELEMENT	ORIGINAL	PROPOSED
301	60	65
306	60	55
501	60	59
701	60	57
901	60	54
906	52	51
616	56	55
815	59	57
912	60	55
915	60	55
1011	60	59
1014	60	58
619	60	59
621	51	50
622	59	50
623	51	50
625	60	59
926	60	57
921	60	58
1022	61	59
1060	63	59
1090	63	60

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MICHOUD OPERATIONS

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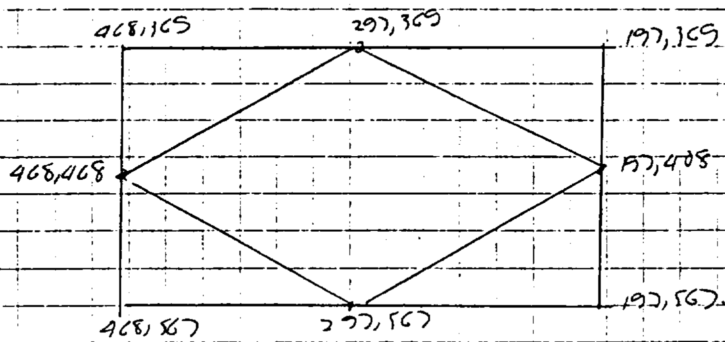
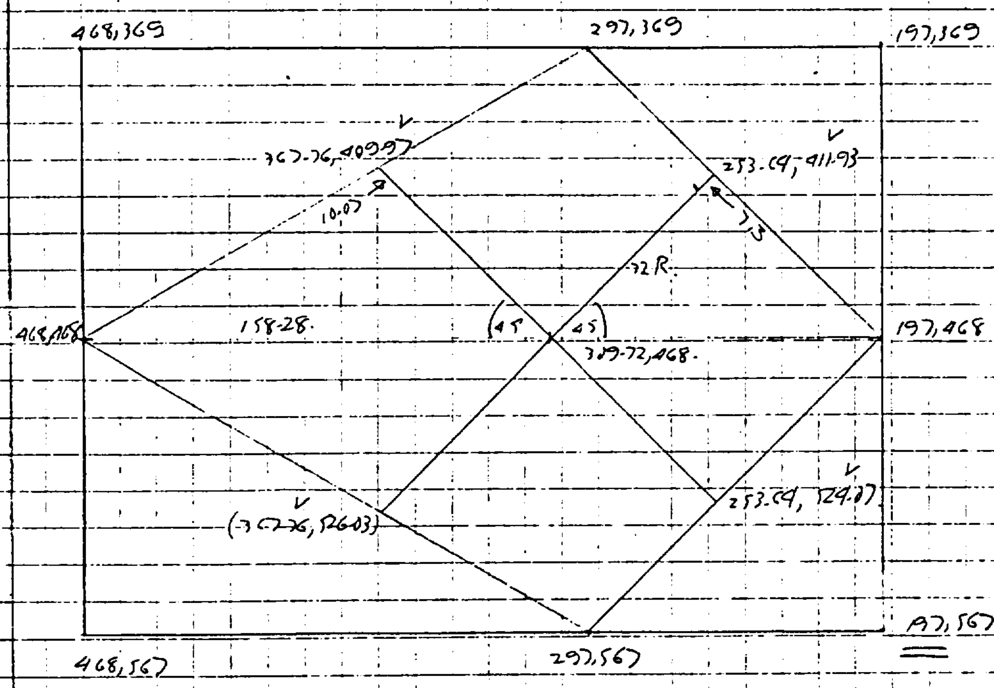
NEW GEOMETRY - EL 115 & 125



EL 115



EL 125

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MICHOUD OPERATIONS

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JC DATE 3/30 SUBJECT PFBTS

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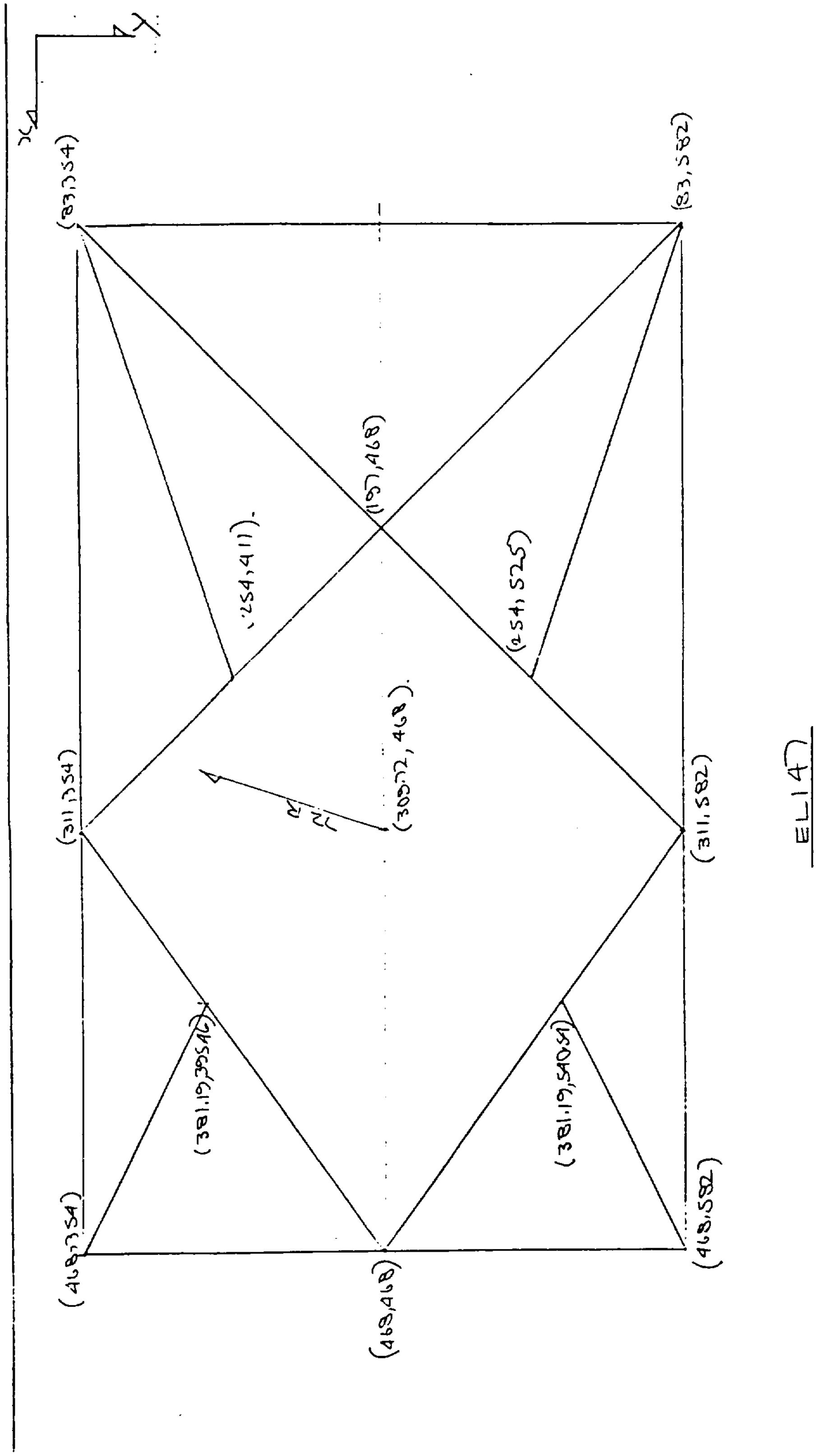
NEW GEOMETRY - EL 147



MARTIN MARIETTA
MICHOUD OPERATIONS

SHEET ___ OF 3-8

JC DATE 3/30 SUBJECT DFBTS

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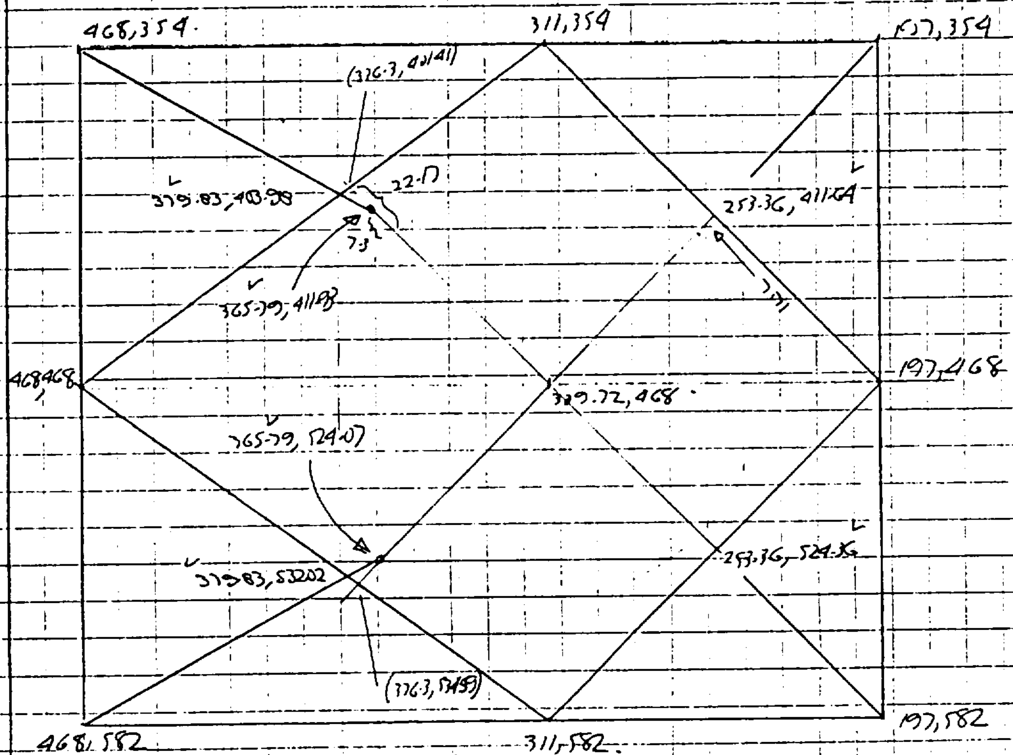
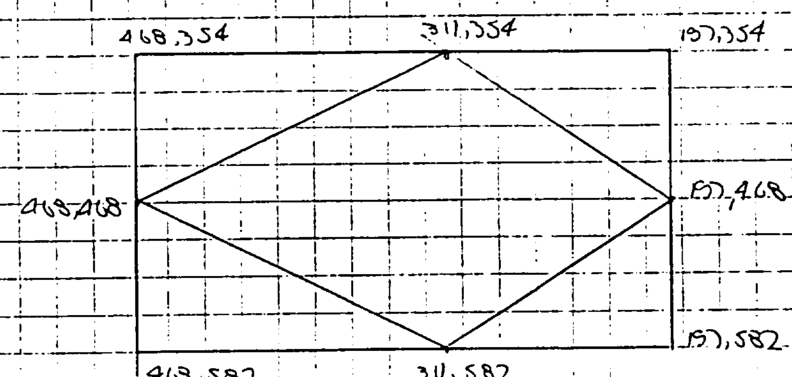
NEW GEOMETRY - EL169 & 157



EL 169.



EL157

MARTIN MARIETTA
MICHOUD OPERATIONS

SHEET ____ OF 39

J C DATE 3/30 SUBJECT PFBTS

WORK PACKAGE

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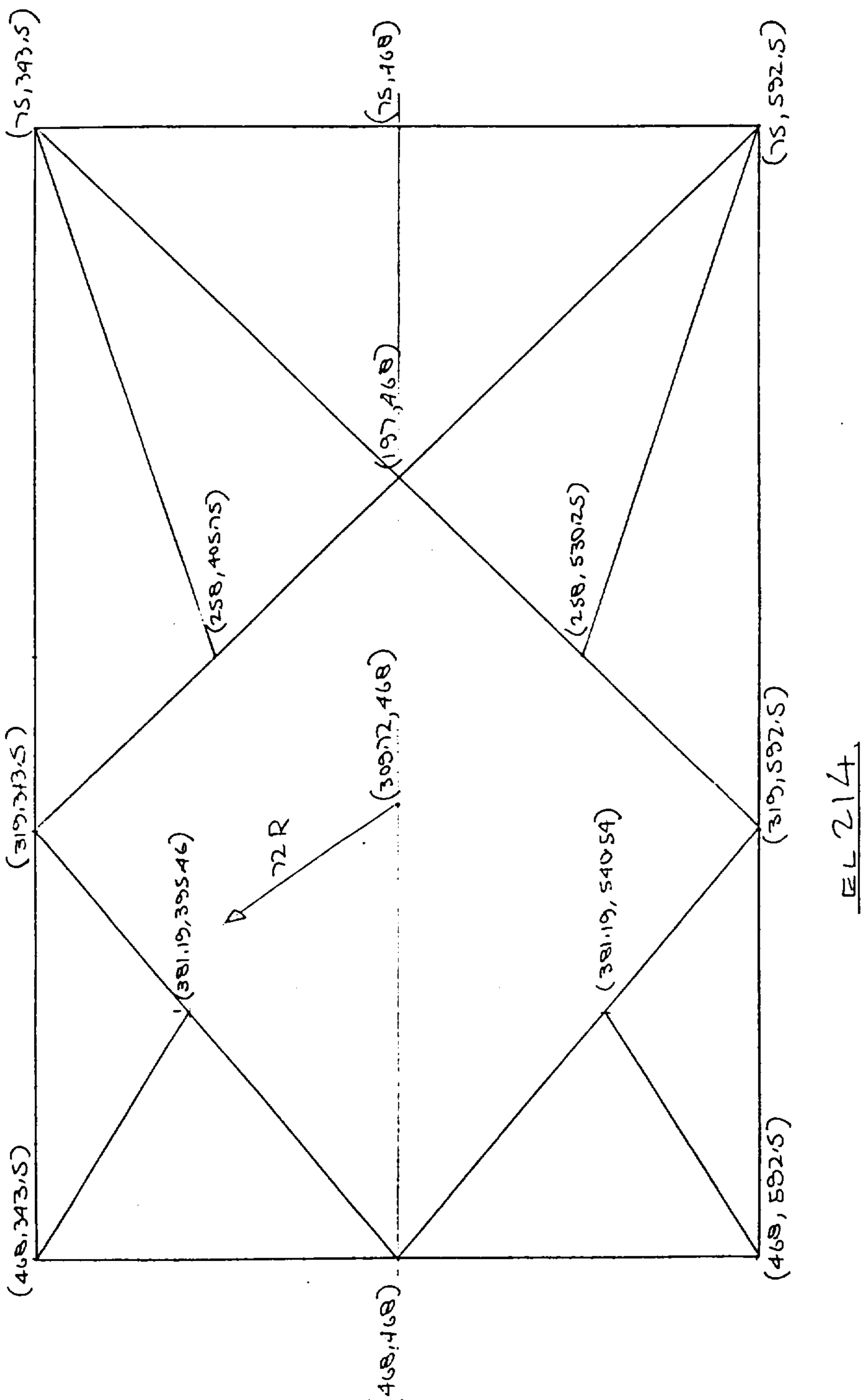
NEW GEOMETRY - EL. 214



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MARTIN MARIETTA
MICHOUD OPERATIONS

SHEET ____ OF 4-1

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THIS SECTION CONTAINS THE LOADSETS USED IN DERIVING MODEL LOADS; I.E.

ORIGINAL LOADSET (MOSS - 9/22/88) PP 39-50 - WIND.
MODIFIED LOADSET (MOSS & GUARIN - 12/1/88) PP1-31 - SEISMIC.

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EL 70'-8" (ROLLING DECK)

MEMBER	WT	LENGTH	TOTAL
12WF27	27	410	11070
27WF94	94	88	8272
30WF132	132	88	11616
2FF79.9	79.9	184	14701
GRATING	18	1684	30312
DECKING	8.7	1684	14651
HR/TP	12.5	100	1250
			91 872
16" PIPE	65	44	2860
16WF40	40	100	4000
8WF17	17	192	3264
24WF160	160	92	14720
24WF130	130	82	10660
12WF53	53	46	2438
RAIL	112	175	8400
GRATING	18	650	11700
DECKING	8.7	650	5655
HR/TP	12.5	50	625
			64,322
			+ 91,872
			156,194

$$\text{CONC. TOWER} = 69.6\left(\frac{70.67-65}{2} + \frac{96.38-70.67}{2}\right) = 1092^{k}$$

156.2
+ 1092

∴ TOTAL = 1248

Prepared By: J. MOSS / 9.22.88 Date

Checked By: ______ / ______ Date

WYLE LABORATORIES (Eastern Operations)

EL 96-4½ (LOAD PLATFORM)

MEMBER	WT	LENGTH	TOTAL
14WF176	176	90	15840
∠4×3×5/16	7.2	18	130
10WF21	21	42	882
8WF17	17	56	952
14WF103	103	58	5974
10WF29	29	14	406
14WF61	61	14	854
8B13	13	70	910
GRATING	6.1	576	3513
HR & TP	12.5	70	875
			30336
			× 2
			60,672
			= 60.67K

$$\text{CONC. TOWER} = 69.6\left(\frac{96.38-70.67}{2} + \frac{105-96.38}{2}\right) \qquad +1194.66$$

1255

Prepared By: J. MOSS 9.22.88 Date Checked By: ______ Date

WYLE LABORATORIES (Eastern Operations)

EL 105'-0" PLAN (TOP OF CONC. TOWERS)

MEMBER	WT	LENGTH	TOTAL
G5	1200	28	33600
G4	1200	28	33600
G1	1020	14	14280
G3	1100	25	27500
18WF 105	105	22	2310
12WF 40	40	96	3840
10B15	15	84	1260
10WF21	21	75	1575
18 WF105	105	62	6510
GRATING	6.1	960	5856
HR & TP	12.5	120	1500
			131,831
			X 2
			263662

$= 264^{K}$

CONC. TOWER $= 69.6\left(\frac{105-96.28}{2}\right) =$ $+\ 300$

564^{K}

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Checked By: / Date

WYLE LABORATORIES (Eastern Operations)

EL 125'-8" SEISMIC WT, W

PLAN	1/2	136-0	1/2 (5682)	
		125-8	37670	
	1/2	115-4	1/2 (9510)	
EL		136-0	38772	
		125-8	45966	
STAIRS			2000	
			132,000	
TANK (RP1)		1/2 TANK	~~330,425~~	165,213
FUEL LINES		12" Φ x 20 FT	4500	
		6" Φ x 20 FT	563	
		14" Φ x 20 FT	6000	
		10.75Φ x 20 FT	428	
FIREX		20" Φ x 20 FT	4840	
			~~478,756~~	16 177,544
ADD FOR 4", 6", 8" FIREX,			+6,244	
TUBING, ELECT., MISC			~~485,000~~	~~≈ 485 K~~
			183,788	≈ 184 K

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WYLE LABORATORIES [Eastern Operations]

EL 146'-4" SEISMIC WT, W

PLAN	1/2	157-8	1/2 (9760)
		146-4	44107
	1/2	136-0	1/2 (5682)
EL		157-8	45782
		146-4	39372
STAIRS			2000
			139,000 lb
FUEL LINES		6" Φ x 35 FT	2100
		10.75 Φ x 35 FT	665
		12" Φ x 10 FT	2166
		12" Φ x 10 FT	2250
		6" Φ x 10 FT	281
		14" Φ x 10 FT	3000
		10.75 Φ x 10 FT	214
FIREX		20" Φ x 10 FT	2420
"		14" Φ x 10 FT	1220
			153,316
ADD FOR MISC			6,684
			160,000 ≈ 160 K
1/2 RP-1 TANK			165 K
			325 K

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PREPARED BY

WYLE LABORATORIES (Eastern Operations)

EL 169'-0" SEISMIC WEIGHT, W

PLAN	½	191-8	½ (14262)
		180-4	9343
		169-0	50689
	½	157-8	½ (8760)
EL		191-8	23936
		180-4	23344
		169-0	31861
STAIRS			3000
			154,000 lb
TANK	(½ LO2)		383,773
FUEL LINES	12"Φ x 30 FT		6500
FIREX	14"Φ x 30 FT		3660
			547,933
ADD FOR MISC			7,067
			555,000 ≈ 555 K

Prepared By: J. MOSS / 9.22.88
Date

Checked By: /
Date

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EL 214'-4" SEISMIC WEIGHT, W

PLAN	241-10	2307
	231-10	3945
	223-1	1440
	214-4	59439
	203-0	8241
1/2	191-8	1/2 (14262)
EL	241-10	2494
	231-10	2230
	223-1	2236
	214-4	19686
	203-0	23011
STAIRS		3500
		136,000 lb
TANK (1/2 LO2)		383,773
FUEL LINES 12" Φ x 35 FT		7,000
FUEL " 12" Φ x 20 FT		4333
FIREX 14" Φ x 20 FT		2440
		533,546 lb
ADD FOR MISC		6,454
		540,000 ≈ 540K

Prepared By: J. MOSS / 9.22.88 Checked By: ______ / ______

Date Date

SECTION 3: CALCULATE THE SEISMIC LOADS TO EACH LEVEL

THIS SECTION IS THE CALCULATION OF THE LATERAL LOADS FOR EACH LEVEL.

THE PROCEDURE IS TAKEN FROM TM5-809-10, FEB 1982, CHAPTERS 3 : A. THIS PROCEDURE IS INTENDED FOR "REGULAR" STRUCTURES.

THIS STRUCTURE IS AN "IRREGULAR" STRUCTURE AND SHOULD BE LOOKED AT CONSIDERING DYNAMICS OF THE STRUCTURE.

SEISMIC LOADS:

LEVEL	h (FT)	W (K)	Wh	$\frac{Wh}{\Sigma Wh}$	F (E-W) (K)
TOP OF EXIST. LOX TANK	214.33	540	115,738	.162	72.25
BTM. OF EXIST. LOX TANK	169.00	555	93,795	.132	58.87
TOP OF EXIST. RP-1 TANK	146.33	325	47,557	.067	29.88
BTM. EXIST RP-1 TANK	125.67	184	23,123	.032	14.27
TOP OF CONC. TOWERS	105.00	564	59,220	.083	37.02
TOP OF LOAD PLATFORM	96.38	1255	120,957	.170	75.82
TOP OF ROLLING DECK	70.67	1,248	88,196	.124	55.30
TOP OF ASPIRATOR	65.00	2527	164,255	.230	102.58
BASE	0	2262	0	0	0
		9460.0	712,841	1.00	446^K O.K.

SEISMIC LOADS @ EA. LEVEL.

$V = ZIKCSW$, $V = (3/16)(1.5)(1.33)(.14)(9460) = 495^K$

$F_{LEVEL\,n} = \dfrac{(V - F_t)\, w_n h_n}{\sum_{i=1} w_i h_i}$, $F_t = .07TV$, $T = \left(\dfrac{.05(214.5)}{\sqrt{57}}\right) = 1.42 SEC$

$\therefore F_t = (.07)(1.42)(495) = 49.2^K$

$V - F_t = 495 - 49.2 = 445.8 \rightarrow 446^K$

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SECTION 6 EL 105'-0" → 241'-10" WIND LOADS

THIS SECTION DETERMINES THE WIND LOADS ON THE TEST STAND FROM 105'-0 & UP. THIS SECTION OF THE TOWER IS ESTABLISHED AS A "TRUSSED TOWER". THEREFORE, AN PROJECTED / TOTAL AREA RATIO MUST BE CALCULATED TO DETERMINE THE FORCE COEFF, C_F.

THE WIND IS CONSIDERED IN A NORTH-SOUTH & EAST-WEST DIRECTION.

ALL REFERENCES / EQUATIONS IN SECTIONS 6 & 7 ARE FROM ANSI A58.1.

Prepared By: J. MOSS / 9.22.88 Date

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WYLE LABORATORIES (Eastern Operations)

NORTH - SOUTH WIND EL 105'-0" TO 241'-10"

AREA BETWEEN COL 1 & 2 @ COL LINE B

MEMBER	LENGTH (FT)	WIDTH (IN)	AREA (FT^2)
14WF48	490	8	327
12WF40	50	12	50
12WF65	25	12	25
24WF76	25	24	50
14WF193	46	16	61
14WF68	45	10	38
14WF61	17	10	14
			565

AREA BETWEEN COL 2 & 3 @ COL LINE B

SIDING	15	137 FT	2055
PIPING, TANKS, MISC, ETC			1454
			4074 FT^2

TOTAL AREA $39(110) + 14(27.5) = 4675\ FT^2$

$$\varepsilon = \frac{\text{PROJECTED}}{\text{TOTAL}} = \frac{4074}{4675} = .87$$

$$C_F = 1.3 + .7\varepsilon = 1.91$$

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WYLE LABORATORIES (Eastern Operations)

EAST-WEST WIND EL 105'-0" TO 241'-10"

CRANE SUPPORT @ COL LINE 3

MEMBER	LENGTH (FT)	WIDTH (IN)	AREA (FT^2)
14WF68	11	10	9
12WF27	19	12	19
2 7Γ 4 X 3 X 1/4	19	4	6
2 7Γ 3 1/2 X 2 1/2 X 1/4	12	3 1/2	4
2 7Γ 2 1/2 X 2 X 1/4	6	2 1/2	1
2 7Γ 8 X 6 X 7/16	22	8	15
14WF61	40	10	33
			87

AREA BETWEEN C & D @ COL LINE 3

12WF27	16	12	16
8WF24	64	8	43
12WF40	64	12	64
SIDING	11	16 FT	176
14WF142	36	16	48
14WF119	45	14	53
14WF43	17	8	11
14WF193	36	16	48
14WF167	45	16	60
14WF136	17	16	23
2 7Γ 8 X 6	57	8	38
12WF53	19	12	19
2 7Γ 4 X 3	95	4	32
			631

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WYLE LABORATORIES (Eastern Operations)

AREA BETWEEN B & C ¢ COL LINE 3

MEMBER	LENGTH	WIDTH	AREA
24WF76	26	24	52
12 WF 65	20	12	20
14 WF 61	46	10	38
12 WF 53	46	12	46
12 WF 99	19	12	19
24WF94	46	24	92
12 WF 79	46	12	46
12 WF 58	17	12	17
14 WF 78	23	14	27
14 WF 43	22	14	26
2 7Γ 8x6	276	8	184
2 7Γ 3½x2½	96	3½	28
2 7Γ 4x3	34	4	11
12 WF 161	34	12	34
12 WF 99	32	12	32
8 WF 24	36	8	24
			696

AREA BETWEEN A & B ¢ COL LINE 3

SIDING	17	137	2329
TANKS, PIPING, ETC			1454
TOTAL PROJECTED AREA =			5197

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WYLE LABORATORIES (Eastern Operations)

TOTAL AREA

$$78(110) + 11(19) + (19)34(1/2) = 9112$$

$$\varepsilon = \frac{5197}{9112} = .57$$

$$c_f = 1.0 + .75\varepsilon = 1.43$$

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WYLE LABORATORIES (Eastern Operations)

DETERMINE WIND LOADS

$F = q_z G_h C_f A_f$

$q_z = 0.00256 K_z (IV)^2$

$K_z = 1.79$ TABLE 6 EXPOSURE C
$I = 1.07$ TABLE 5 CAT III
$V = 70$ MPH

$q_z = 0.00256 (1.79) (1.07(70))^2 = 25.7$ PSF

$G_h = 1.1$ TABLE 8 EXPOSURE C

$F_{N-S} = 25.7 (1.1)(1.91)\ 4074 = 219,978^{lb} = 220^K$

$F_{E-W} = 25.7 (1.1)(1.43)\ 5197 = 210,094 = 210^K$

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WYLE LABORATORIES (Eastern Operations)

DETERMINE DIAPHRAGM DISTRIBUTION -

(BASED ON GROSS AREAS)

TOTAL AREA N-S = 4675 FT^2

125'-8" $\frac{39(20-8)}{4675}$ 220 = 38^K

146'-8" $\frac{39(21-8)}{4675}$ 220 = 40^K

169'-0" $\frac{39(34)}{4675}$ 220 = 63^K

214'-4" $\frac{39(22-8)+27(14)}{4675}$ 220 = 60^K

→ 105'-0" $\frac{39(10-4)}{4675}$ 220 = 19^K

220^K

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WYLE LABORATORIES (Eastern Operations)

TOTAL AREA E-W = 5197

125'-8"	$\frac{38}{220}$	210	=	36^K
146'-8"	$\frac{40}{220}$	210	=	38^K
169'-0"	$\frac{63}{220}$	210	=	60^K
214'-4"	$\frac{60}{220}$	210	=	58^K
105'-0"	$\frac{19}{220}$	210	=	18^K
				210^K

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WYLE LABORATORIES (Eastern Operations)

SECTION 7 ELEV 105'-0" & BELOW

THIS SECTION WILL DETERMINE THE WIND LOADING ON THE TEST STAND CONCRETE COLUMNS.

A SUMMARY IS INCLUDED AT THE END.

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WYLE LABORATORIES (Eastern Operations)

DETERMINE LOAD BELOW 105'-0" (N-S)

CONCRETE COLUMNS (18+16)(105) = 3570 FT²

ASPIRATOR @ 65'-0" 25'(2-8) = 67

GIRDER @ EL 105'-0 25'(10') = 250

PLATFORM @ EL 70'-8 (25+26)(5) = 255

4142 FT²

DEFLECTOR IS INDEPENDENT OF CONCRETE COLUMNS. WIND PROJECTED ON DEFLECTOR WILL NOT AFFECT CONCRETE COLUMNS.

WIND FORCE $h/D = 242/76 = 3.2$

$F_{N-S} = q_z G_h C_f A_f$ $C_f = 1.35$ TABLE 12

$= 25.7(1.1)\,1.35(4142)$

$= 158{,}077^{lb} = 158^K + 19^K$ (FROM 105'-0")

$= 177^K$

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WYLE LABORATORIES (Eastern Operations)

E-W DIRECTION

CONCRETE COLUMNS	(18+18) 105	=	3780
ASPIRATOR	44′(2-8)	=	117
GIRDER	44′ (10)	=	440
PLATFORM	5′ (44)	=	220
			4557

$F_{E-W} = q_z G_h C_f A_f$ $\qquad h/D = 242/57 = 4.2$

$= 25.7 (1.1) 1.4 (4557)$ $\qquad C_f = 1.4$ TABLE 12

$= 180,357$

$= 180^K + 18$ (FROM 105-0)

$= 198^K$

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WYLE LABORATORIES (Eastern Operations)

LOAD SUMMARY

LEVEL	SEISMIC N-S	SEISMIC E-W	WIND N-S	WIND E-W
125-8	13 K	13 K	38 K	36 K
146-8	5	5	40	38
169-0	21	21	63	60
214-4	69	76	60	58
BELOW 105'-0"	403	396	177	198
	511 K	511 K	378 K	390 K

LOADS AT 125-8, 146-8, 169-0 & 214-4 SHOULD BE DISTRIBUTED EVENLY AT THESE LEVELS.

LOADS BELOW 105'-0" SHOULD BE APPLIED UNIFORMLY ON THE CONCRETE TOWERS.

Prepared By: J. MOSS / 9.22.88 Date

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PRESSURE FED BOOSTER

SEISMIC LOADS

F-1 TEST STAND MODIFICATIONS

BY:

JEFF MOSS / JIMMY GUARIN.

12/1/88

ASSUMPTIONS:

1) NEW DESIGN WILL BE SIMILAR TO EXISTING TEST STAND IN WEIGHT & MEMBER SIZE.

2) ALL STRUCTURAL MEMBERS ARE TAKEN FROM EXISTING DWGS SUPPLIED BY NASA.

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SECTION 1 ELEV 105-0 → 241-10 WT TAKE OFF

THIS SECTION IS A MEMBER WEIGHT TAKE OFF OF THE TEST STAND FROM ELEV 105'-0" TO THE TOP OF THE TEST STAND ELEV 241'-10"

THOSE MEMBERS LISTED UNDER "PLAN" ARE TAKEN FROM THE PLAN DRAWINGS AND INCLUDE FLOOR BEAMS, GIRDERS, GRATING AND/OR CHECKERED PLATE, HANDRAIL AND TOEPLATES.

THOSE MEMBERS LISTED UNDER "ELEV" ARE TAKE FROM THE ELEV DRAWINGS AND INCLUDE X-BRACING, COLUMNS, ETC.

ALL REFERENCES/EQUATIONS ARE FROM TM 5-809-10, FEB 1982.

Prepared By: J. MOSS / 9.22.88
Date

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Date

PREPARED BY

WYLE LABORATORIES (Eastern Operations)

EL 115-4 PLAN (FLOOR BEAMS, GRATING, HR, ETC)

MEMBER	WT (lb/FT)	LENGTH (FT)	TOTAL (lb)
⊓ 5x3½x3/8	20.8	88	1830
8WF24	24	120	2880
14WF48	48	50	2400
2⊓ 3x2½x¼	9.0	30	270
12WF50	50	16	800
12WF58	58	16	928
5[6.7	6.7	60	402
			9510

(½ TRANSFERS TO ELEV 105'-0")

ELEV (X-BRACING, COLUMNS, ETC.)

2⊓6x4x3/8	24.6	34	836
14WF48	48	68	3264
12WF92	92	36	3312
2⊓7x4x3/8	27.2	40	1088
2⊓4x3x¼	11.6	36	418
12WF99	99	36	3564
14WF61	61	41	2501
14WF43	43	21	903
14WF193	193	62	11966
14WF142	142	62	8804
14WF167	167	21	3507
			40,163 ✓

(TRANSFERS TO ELEV 105'-0")

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WYLE LABORATORIES (Eastern Operations)

EL 125'-8" PLAN

MEMBER	WT	LENGTH	TOTAL
12WF27	27	315	8505
12WF40	40	168	6720
12WF72	72	46	3312
12WF65	65	51	3315
2 ∟ 8×6×½	46	78	3588
12WF79	79	46	3634
BEAM	211	33	6963
STAIR PLATFORM 8C 11.5	11.5	23	265
10WF21	21	14	294
8 I 18.4	18.4	16	294 — 1231 lb
GRATING	6.1	21	128
HR & TP	12.5	20	250
5C 6.7	6.7	60	402
			37670 ✓
ELEV			
2 ∟ 5×3½×⅜	20.8	34	707
14WF48	48	68	3264
2 ∟ 8×4×⅝	50.6	34	1720
2 ∟ 8×6×7/16	40.4	52	2101
2 ∟ 6×4×⅜	24.6	34	836
2 ∟ 4×3×¼	11.6	34	394
2 ∟ 8×6×¾	67.6	34	2298

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WYLE LABORATORIES (Eastern Operations)

EL 125'-8" CONT'D

14WF 61	61	41	2501
14 WF 43	43	63	2709
14WF 193	193	62	11966
14 WF 142	142	62	8804
14 WF 167	167	21	3507
14 WF 103	103	32	3296
2L 8x6x7/16	40.4	30	1212
2L 5x3x5/16	16.4	10	164
2L 2 1/2x2x1/4	7.2	10	72
2L 4x3x1/4	11.6	10	116
2L 7x4x3/8	27.2	11	299
			45,966 ✓

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WYLE LABORATORIES (Eastern Operations)

EL 136'-0" PLAN

MEMBER	WT	LENGTH	TOTAL
8WF24	24	120	2880
14WF48	48	50	2400
5[6.7	6.7	60	402
			5682 ✓

ELEV

2 7[5 X 3½ x 3/8	20.8	34	707
14WF48	48	68	3264
2 7[8 x 6 x 3/4	67.6	32	2163
2 7[6 x 4 x 3/8	24.6	36	886
2 7[8 x 6 x 5/8	57.0	32	1824
2 7[4 x 3 x 1/4	11.6	38	441
14WF61	61	41	2501
14WF43	43	63	2709
14WF193	193	62	11966
14WF142	142	62	8804
14WF167	167	21	3507
			38772 ✓

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WYLE LABORATORIES (Eastern Operations)

EL 146'-4" PLAN

	MEMBER	WT	LENGTH	TOTAL
	6B12	12	307	3684
	12WF27	27	60	1620
	12WF40	40	110	4400
	2 ⌐ 2½x2½x¼	8.2	175	1435
	24WF76	76	124	9424
	24WF94	94	46	4324
	12B16.5	16.5	38	627
	8[11.5	11.5	28	322
	12B19	19	19	361
	7[9.8	9.8	44	431
	5[6.7	6.7	60	402
	GRATING	6.1	1561	9522
	HR & TP	12.5	222	2775
STAIR PLATFORM	6[8.2	8.2	4	33
	8[11.5	11.5	32	368
	8 I 18.4	18.4	16	294
	10WF21	21	14	294
	GRATING	6.1	64	390
	HR & TP	12.5	20	250
	2 ⌐ 8x6x7/16	40.4	78	3151
				44,107

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WYLE LABORATORIES (Eastern Operations)

EL 146'-4" CONT'D

ELEV

2 ⅂Γ 5 x 3 ½ x ⅜	20.8	34	707
14 WF 48	48	68	3264
2 ⅂Γ 4 x 3 x ¼	11.6	70	812
2 ⅂Γ 6 x 4 x ⅜	24.6	38	935
2 ⅂Γ 8 x 6 x ¾	67.6	32	2163
2 ⅂Γ 3½ x 2½ x ¼	9.8	30	294
2 ⅂Γ 8 x 6 x ⅝	57.0	30	1710
14 WF 61	61	41	2501
14 WF 43	43	63	2709
14 WF 193	193	62	11966
14 WF 142	142	62	8804
14 WF 167	167	21	3507
			39372

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WYLE LABORATORIES (Eastern Operations)

EL 157'-8" PLAN

MEMBER	WT	LENGTH	TOTAL
8WF24	24	120	2880
14WF48	48	50	2400
12WF72	72	18	1296
12WF99	99	18	1782
5[6.7	6.7	60	402
			8760 ✓

ELEV

2][5 x 3½ x ⅜	20.8	34	707
14WF48	48	68	3264
12WF161	161	68	10948
2][6 x 4 x ⅜	24.6	38	935
2][4 x 3 x ¼	11.6	38	441
14WF61	61	41	2501
14WF43	43	63	2709
14WF193	193	62	11966
14WF142	142	62	8804
14WF167	167	21	3507
			45782 ✓

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WYLE LABORATORIES (Eastern Operations)

EL 169'-0" PLAN

MEMBER	WT	LENGTH	TOTAL
12 WF 27	27	172	4644
12 WF 40	40	172	6880
12 WF 65	65	96	6240
12 WF 53	53	75	3975
12 WF 85	85	36	3060
8 C 11.5	11.5	32	368
2∠ 8X6X1	88.4	78	6895
24WF100	100	28	2800
36 WF194 W/PL	213	38	8094
STAIR PLATFORM			1231
2∠ 8 X 6 X 7/8	78.2	78	6100
5C 6.7	6.7	60	402
			50,689✓
ELEV			
2∠ 5X3½X5/16	16.4	36	590
14WF48	48	50	2400
2∠ 4X3X¼	11.6	34	394
2∠ 8X6X½	46.0	28	1288
2∠ 6X3½X5/16	19.6	38	745
2∠ 4X3X¼	11.6	59	684
2∠ 8X6X7/16	40.4	28	1131
			7232

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WYLE LABORATORIES (Eastern Operations)

EL 169'-0" CONTD

14WF43	43	83	3569
14WF61	61	41	2501
14WF68	68	62	4216
14WF167	167	21	3507
14WF119	119	21	2499
14WF78	78	21	1638
14WF103	103	31	3193
2 L 8×6×7/8	78.2	27	2111
2 L 7×4×7/16	35.8	11	394
2 L 3×2½×¼	6.8	11	75
2 L 7×4×3/8	27.2	11	299
2 L 8×6×5/8	57.0	11	627
			24629
			+ 7232
			31861

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WYLE LABORATORIES (Eastern Operations)

EL 180'-4" PLAN

MEMBER	WT	LENGTH	TOTAL
8WF24	24	120	2880
14WF48	48	50	2400
2 ∟ 2¼ x 2 x ¼	7.2	6	43
5C6.7	6.7	60	4020
ELEV			9343 ✓
2 ∟ 5 x 3½ x 5/16	16.4	36	590
14WF48	48	50	2400
2 ∟ 8 x 6 x 7/16	40.4	64	2586
2 ∟ 5 x 3½ x 5/16	16.4	38	623
14WF61	61	13	793
12WF53	53	20	1060
2 ∟ 4 x 3 x ¼	11.6	19	220
14WF43	43	83	3569
14WF61	61	21	1281
14WF68	68	62	4216
14WF167	167	21	3507
14WF119	119	21	2499
			23344 ✓

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WYLE LABORATORIES (Eastern Operations)

EL 191'-8" PLAN

MEMBER	WT	LENGTH	TOTAL
8WF24	24	28	672
12WF40	40	60	2400
12WF27	27	32	864
14WF 48	48	50	2400
14WF61	61	92	5612
8 [11.5	11.5	16	184
2 ⅃⌊ 2½ x 2 x ¼	7.25	51	370
2 ⅃⌊ 3½ x 2½ x ¼	9.8	13	127
5[6.7	6.7	60	402
STAIR PLATFORM			1231
			14262 ✓

ELEV

MEMBER	WT	LENGTH	TOTAL
2 ⅃⌊ 4 x 3 x ¼	11.6	36	418
14WF48	48	50	2400
2 ⅃⌊ 4 x 3 x ¼	11.6	83	963
2 ⅃⌊ 8 x 6 x 7/16	40.4	83	3353
2 ⅃⌊ 5 x 3 x 5/16	16.4	38	623
14WF61	61	13	793
2 ⅃⌊ 3½ x 2½ x ¼	9.8	32	314
14WF43	43	83	3569
14WF61	61	21	1281
14WF68	68.	62	4216
14WF167	167	21	3507
14WF119	119	21	2499
			23936 ✓

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WYLE LABORATORIES (Eastern Operations)

EL 203'-0" PLAN

MEMBER	WT (#/FT)	LENGTH	TOTAL
12WF40	40	29	1160
6B16	16	25	400
8WF24	24	120	2880
12WF27	27	23	621
2∟ 4x3x 1/4	11.6	19	220
14WF48	48	50	2400
2∟ 2 1/2 x2x 1/4	7.2	22	158
5[6.7	6.7	60	402
			8241

ELEV

2∟ 4x3x 1/4	11.6	36	418
14WF48	48	50	2400
2∟ 8x6x 7/16	40.4	83	3353
2∟ 4x3x 1/4	11.6	57	661
14WF61	61	13	793
2∟ 3 1/2 x 2 1/2 x 1/4	9.8	32	314
14WF43	43	83	3569
14WF61	61	21	1281
14WF68	68	62	4216
14WF167	167	21	3507
14WF119	1.19	21	2499
			23011.

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WYLE LABORATORIES (Eastern Operations)

EL 214'-4" PLAN

MEMBER	WT (lb/FT)	LENGTH (FT)	TOTAL (lb)
6 B 12	12	315	3780
2][2½ x 2½ x ¼	8.2	157	1287
12 WF 27	27	109	2943
12 WF 40	40	94	3760
24 WF 76	76	227	17272
12 C 20.7	20.7	26	538
12 WF 65	65	21	1365
7 C 9.8	9.8	28	274
8 C 11.5	11.5	235	2704
12 B 22	22	30	660
6 B 16	16	37	592
6 WF 15.5	15.5	10	155
12 B 19	19	21	399
12 B 16.5	16.5	21	347
6 C 8.2	8.2	12	98
10 WF 21	21	14	294
8 I 18.4	18.4	16	294
8" PIPE	43.4	180	7812
5 C 6.7	6.7	60	402
GRATING	6.1 lb/SF	1921 SF	9888
HR & TP	12.5 lb/F	366	4575
			59,439

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WYLE LABORATORIES (Eastern Operations)

EL 214'-4" CONT'D

ELEV

2 7 ⌐ 3 1/2 x 2 1/2 x 1/4	9.8	36	353
14 WF 48	48	50	2400
2 7 ⌐ 4 x 3 x 1/4	11.6	70	812
2 7 ⌐ 8 x 6 x 7/16	40.4	73	2950
8 WF 24	24	34	816
2 7 ⌐ 6 x 4 x 3/8	24.6	18	443
14 WF 43	43	165	7095
14 WF 61	61	21	1281
14 WF 136	136	21	2856
14 WF 68	68	10	680
			19686

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WYLE LABORATORIES (Eastern Operations)

EL 223'-1" PLAN

MEMBER	WT	LENGTH	TOTAL
8WF24	24	28	672
8WF24	24	32	768
			1440

ELEV

2 ⅂Γ 4x3x1/4	11.6	38	441
2 ⅂Γ 3 1/2x2 1/2x1/4	9.8	29	284
14WF43	43	35	1505
			2230

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WYLE LABORATORIES (Eastern Operations)

EL 231'-10" PLAN

MEMBER	WT	LENGTH	TOTAL
8WF24	24	28	672
16WF50	50	16	800
16WF40	40	16	640
8[11.5	11.5	42	483
DECKING	11.25	120SF	1350
			3945

ELEV

2 7Γ 3½ x 2½ x ¼	9.8	29	284
2 7Γ 4 x 3 x ¼	11.6	38	441
14WF43	43	35	1505
			2230

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WYLE LABORATORIES (Eastern Operations)

EL 241'-10" PLAN

MEMBER	WT	LENGTH	TOTAL
6[8.2	8.2	157	1287
8WF17	17	60	1020
			2307

ELEV

2 7[3½ x 2½ x ¼	9.8	34	333
2 7[4 x 3 x ¼	11.6	38	441
14WF43	43	40	1720
			2494

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SECTION 2: DETERMINE THE WTS TO DIAPHRAMS

THIS SECTION SUMMARIZES THE WEIGHTS THAT ARE DISTRIBUTED TO EACH APPLICABLE LEVEL FROM THE GROUND TO 2/4-4.

REPLACES

WYLE LABORATORIES (Eastern Operations)

EL 65-0" (ASPIRATOR)

MEMBER	WT	LENGTH	TOTAL
33WF240	240	112	26880
G-1	54	48	2592
G-2	54	54	2916
G-3	54	20	1080
TRUSS I	27	160	4320
TRUSS II	25	256	6400
33WF152	152	76	11552
1/4 CHKD PL	11.25	1096	12330
			68,070

CONC. TOWER $= [16(18) - 12(14)]$ 4 COLUMNS $(145^{lb}/_{CF})\left(\frac{65}{2} + \frac{70.67-65}{2}\right)$

$= (288 - 168)(580)(35.34)$

$= 2459$

TOTAL = 68 + 2459

= 2527 K

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WYLE LABORATORIES (Eastern Operations)

EL 70'-8" (ROLLING DECK)

MEMBER	WT	LENGTH	TOTAL
12WF27	27	410	11070
27WF94	94	88	8272
30WF132	132	88	11616
2FF79.9	79.9	184	14701
GRATING	18	1684	30312
DECKING	8.7	1684	14651
HR/TP	12.5	100	1250
			91872
16" PIPE	65	44	2860
16WF40	40	100	4000
8WF17	17	192	3264
24WF160	160	92	14720
24WF130	130	82	10660
12WF53	53	46	2438
RAIL	112	175	8400
GRATING	18	650	11700
DECKING	8.7	650	5655
HR/TP	12.5	50	625
			64,322
			+ 91,872
			156,194

CONC. TOWER = $69.6\left(\frac{70.67-65}{2} + \frac{96.38-70.67}{2}\right)$ = 1092^K

156.2^K
+ 1092

∴ TOTAL ≈ 1248

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WYLE LABORATORIES (Eastern Operations)

EL 96-4 1/2 (LOAD PLATFORM)

MEMBER	WT	LENGTH	TOTAL
14WF176	176	90	15840
L4X3X5/16	7.2	18	130
10WF21	21	42	882
8WF17	17	56	952
14WF103	103	58	5974
10WF29	29	14	406
14WF61	61	14	854
8B13	13	70	910
GRATING	6.1	576	3513
HR & TP	12.5	70	875
			30336
			x 2
			60,672

= 60.67^{K}

CONC. TOWER = $69.6\left(\frac{96.38-70.67}{2}+\frac{105-96.38}{2}\right)$ + 1194.66

1255

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WYLE LABORATORIES (Eastern Operations)

EL 105'-0" PLAN (TOP OF CONC. TOWERS)

MEMBER	WT	LENGTH	TOTAL
G5	1200	28	33600
G4	1200	28	33600
G1	1020	14	14280
G3	1100	25	27500
18WF 105	105	22	2310
12WF 40	40	96	3840
10 B 15	15	84	1260
10 WF 21	21	75	1575
18 WF 105	105	62	6510
GRATING	6.1	960	5856
HR & TP	12.5	120	1500
			131,831
			X 2
			263662

= 264^K

CONC. TOWER = $69.6\left(\frac{105-96.28}{2}\right)$ +

+ 300

564^K

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WYLE LABORATORIES (Eastern Operations)

EL 125'-8" SEISMIC WT, W

PLAN	1/2	136-0	1/2 (5682)	
		125-8	37670	
	1/2	115-4	1/2 (9510)	
EL		136-0	38772	
		125-8	45966	
STAIRS			2000	
			132,000	
TANK (RP1)		1/2 TANK	~~330,425~~	165,213
FUEL LINES		12" Ø x 20 FT	4500	
		6" Ø x 20 FT	563	
		14" Ø x 20 FT	6000	
		10.75 Ø x 20 FT	428	
FIREX	20" Ø x 20 FT		4840	
			~~478,756~~	177,544
ADD FOR 4", 6", 8" FIREX, TUBING, ELECT, MISC			6,244	
			~~485,000~~	~~≈ 485K~~
			183,788	≈ 184K

Prepared By: J. Moss 9.22.88 Date

Checked By: ______ / ______ Date

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WYLE LABORATORIES (Eastern Operations)

EL 146'-4" SEISMIC WT, W

PLAN	1/2	157-8	1/2 (8760)
		146-4	44107
	1/2	136-0	1/2 (5682)
EL		157-8	45 782
		146-4	39 372
STAIRS			2000
			139,000 lb
FUEL LINES		6"Φ x 35 FT	2100
		10.75Φ x 35 FT	665
		12"Φ x 10 FT	2166
		12"Φ x 10 FT	2250
		6"Φ x 10 FT	281
		14"Φ x 10 FT	3000
		10.75Φ x 10 FT	214
FIREX		20"Φ x 10 FT	2420
"		14"Φ x 10 FT	1220
			153,316
ADD FOR MISC			6,684
			160,000 ≈ 160 K
1/2 RP-1 TANK			165 K
			325 K

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Date Date

WYLE LABORATORIES (Eastern Operations)

EL 169'-0" SEISMIC WEIGHT, W

PLAN	1/2	191-8	1/2 (14262)
		180-4	9343
		169-0	50689
	1/2	157-8	1/2 (8760)
EL		191-8	23936
		180-4	23344
		169-0	31861
STAIRS			3000
			154,000
TANK (1/2 LO2)			383,773
FUEL LINES 12"Φ x 30 FT			6500
FIREX 14"Φ x 30 FT			3660
			547,933
ADD FOR MISC			7,067
			555,000 ≈ 555 K

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WYLE LABORATORIES (Eastern Operations)

EL 214'-4" SEISMIC WEIGHT, W

PLAN	241-10	2307
	231-10	3945
	223-1	1440
	214-4	59439
	203-0	8241
1/2	191-8	1/2 (14262)
EL	241-10	2494
	231-10	2230
	223-1	2230
	214-4	19686
	203-0	23011

STAIRS 3500

136,000 lb

TANK (1/2 LO2) 383,773

FUEL LINES 12" Φ x 35 FT 7,000

" " 12" Φ x 20 FT 4333

FIREX 14" Φ x 20 FT 2440

533,546 lb

ADD FOR MISC 6,454

540,000 ≈ 540 K

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SECTION 3: CALCULATE THE SEISMIC LOADS TO EACH LEVEL

THIS SECTION IS THE CALCULATION OF THE LATERAL LOADS FOR EACH LEVEL.

THE PROCEDURE IS TAKEN FROM TM5-809-10, FEB 1982, CHAPTERS 3 : A. THIS PROCEDURE IS INTENDED FOR "REGULAR" STRUCTURES.

THIS STRUCTURE IS AN "IRREGULAR" STRUCTURE AND SHOULD BE LOOKED AT CONSIDERING DYNAMICS OF THE STRUCTURE.

SEISMIC LOADS:

LEVEL	h (FT)	W (K)	Wh	$\frac{Wh}{\Sigma Wh}$	F (E-W) (K)
TOP OF EXIST. LOX TANK	214.33	540	115,738	.162	72.25
BTM. OF EXIST. LOX TANK	169.00	555	93,795	.132	58.87
TOP OF EXIST. RP-1 TANK	146.33	325	47,557	.067	29.88
BTM. EXIST RP-1 TANK	125.67	184	23,123	.032	14.27
TOP OF CONC. TOWERS	105.00	564	59,220	.083	37.02
TOP OF LOAD PLATFORM	96.38	1255	120,957	.170	75.82
TOP OF ROLLING DECK	70.67	1,248	88,196	.124	55.30
TOP OF ASPIRATOR	65.00	2527	164,255	.230	102.58
BASE	0	2262	0	0	0
		9460.0	712,841	1.00	446^K O.K.

SEISMIC LOADS @ EA. LEVEL

$V = ZIKCSW$, $V = (3/16)(1.5)(1.33)(.19)(9460) = 495^K$

$F_{LEVEL\,n} = \frac{(V - F_t)\, w_n h_n}{\sum_{i=1} w_i h_i}$ $\quad F_t = .07\,TV$, $T = \left(\frac{.05(214.5)}{\sqrt{57}}\right) = 1.42\,SEC$

$\therefore F_t = (.07)(1.42)(495) = 49.2^K$

$V - F_t = 495 - 49.2 = 445.8 \rightarrow 446^K$

JC DATE 3/30 SUBJECT PFBTS.

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APPROVED ____ DATE ____ REV ____ DATE ____

MODIFIED LOADSET

THIS SECTION CONTAINS SHTS 26-31 OF THE SEISMIC LOADSET MODIFIED TO INCORPORATE:

1) ADDITION OF THE SEISMIC BOTTLE AT LEVEL 125.
2) ADJUSTMENTS TO REFLECT ALTERED TANK LOAD DISTRIBUTION TO THE SUPPORT DIAPHRAGMS

- PRESS BOTTLE AT EL 125
- TRANSVERSE TANK WTS SPLIT 35/65 (LO2)
  74/26 (RP-1)

EL 125'-8" SEISMIC WT, W

PLAN	1/2	136-0	1/2 (5682)	
		125-8	37670	
	1/2	115-4	1/2 (9510)	
EL		136-0	38772	
		125-8	45966	
STAIRS			2000	
			132,000	
		.74 (TANK)		244520
TANK (RP1)		~~1/2 TANK~~	~~330,425~~	~~165,213~~
FUEL LINES		12"φ x 20 FT	4500	
		6"φ x 20 FT	563	
		14"φ x 20 FT	6000	
		10.75φ x 20 FT	428	
FIREX 20"φ x 20 FT			4840	
			~~478,756~~	lb 177,544
ADD FOR 4", 6", 8" FIREX, TUBING, ELECT., MISC			+6,244	
			~~485,000~~	~~≈ 485 K~~
			183,788	≈ ~~484 K~~ 263 K

+ 90 K pressurant tank

353 K

Prepared By: J. Moss Date: 9.22.88

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EL 146'-4" SEISMIC WT, W

PLAN	1/2	157-8	1/2 (9760)
		146-4	44107
	1/2	136-0	1/2 (5682)
EL		157-8	45 782
		146-4	39 372
STAIRS			2000
			139,000 lb
FUEL LINES		6" Φ x 35 FT	2100
		10.75 Φ x 35 FT	665
		12" Φ x 10 FT	2166
		12" Φ x 10 FT	2250
		6" Φ x 10 FT	281
		14" Φ x 10 FT	3000
		10.75 Φ x 10 FT	214
FIREX		20" Φ x 10 FT	2420
		14" Φ x 10 FT	1220
			153,316
ADD FOR MISC			6,684
			160,000 ≈ 160 K
.26 x RP-1 TANK			~~165 K~~ 86 K
~~1/2~~ RP-1 TANK			~~325 K~~ 246 K

Prepared By: J. MOSS 9.22.88
Date

Checked By: /
Date

EL 169'-0" SEISMIC WEIGHT, W

PLAN	1/2	191-8	1/2 (14262)
		180-4	9343
		169-0	50689
	1/2	157-8	1/2 (8760)
EL		191-8	23936
		180-4	23344
		169-0	31861
STAIRS			3000
			154,000 lb
TANK	(~~1/2~~ .35 LO2)		~~383,113~~ 268,640
FUEL LINES	12"Ø x 30 FT		6,500
FIREX	14"Ø x 30 FT		3660
			547,933
ADD FOR MISC			7,067
			555,000 ≈ ~~555~~K 440K

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Date Date

WYLE LABORATORIES (Eastern Operations)

EL 214'-4" SEISMIC WEIGHT, W

PLAN	241-10	2307
	231-10	3945
	223-1	1440
	214-4	59439
	203-0	8241
1/2	191-8	1/2 (14262)
EL	241-10	2494
	231-10	2230
	223-1	2230
	214-4	19686
	203-0	23011

STAIRS	3500
	136,000 lb
(.65)	498,900
TANK (1/2 LOZ)	~~383,773~~
FUEL LINES 12" Φ x 35 FT	7,000
12" Φ x 20 FT	4333
FIREX 14" Φ x 20 FT	2440
	533,546 lb
ADD FOR MISC	6,454
	540,000 ≈ ~~540k~~ 655 K

~~CALC OK FOR PRESURANT TANK = 738 K~~

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Checked By: ______ / ______ Date

SEISMIC LOADS:

LEVEL	h (FT)	W (K)	Wh	Σwh $\frac{wh}{\Sigma wh}$	F (E-W) (K)
TOP OF EXIST. LOX TANK	214.33	~~340~~ 655	~~115,738~~ 140,400	.193 ~~.162~~	~~72.25~~ 86.85
BTM. OF EXIST. LOX TANK	169.00	~~555~~ 440	~~93,795~~ 74360	.102 ~~.132~~	~~58.87~~ 45.9
TOP OF EXIST. RP-1 TANK	146.33	~~325~~ 246	~~47,557~~ 36,000	.050 ~~.067~~	~~29.88~~ 22.5
BTM. EXIST RP-1 TANK	125.67	~~184~~ 353	~~23,123~~ 44362	.061 ~~.032~~	~~14.27~~ 27.45
TOP OF CONC. TOWERS	105.00	564	59,220	~~.083~~ [illegible]	~~37.02~~ 36.9
TOP OF LOAD PLATFORM	96.38	1255	120,957	~~.170~~ [illegible]	~~75.82~~ 74.7
TOP OF ROLLING DECK	70.67	1,248	88,196	.124	55.30 54.45
TOP OF ASPIRATOR	65.00	2527	164,255	~~.230~~	102.58 101.7
BASE	0	2262	0	0	0
		~~9460.0~~ 9550	~~712,844~~ 727,750	1.00	446K OK

SEISMIC LOADS @ EA. LEVEL.

$V = ZIKCSW$, $V = (3/16)(1.5)(1.33)(.14)(\cancel{9460}\ 9550) = \cancel{495}\ 500^K$

$F_{LEVEL\,n} = \dfrac{(V - F_t)\, w_n h_n}{\sum_{i=1} w_i h_i}$, $F_t = .07\,TV$, $T = \left(\dfrac{.05(214.5)}{\sqrt{57}}\right) \approx 1.4250$

$\therefore F_t = (.07)(1.42)(\cancel{495}\ 500) = \cancel{49.2}\ 49.7^K$

$V - F_t = \cancel{495} - \cancel{49.2} = 445.8 \rightarrow \cancel{446^K}$

$500 - 49.7$ $\underline{450^K}$

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MARTIN MARIETTA
MICHOUD OPERATIONS

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DERIVED LOADS - SEISMIC

SEISMIC LOADS:

REF MODIFIED NOTES WITH PRESS. BOTTLE AT EL 125.

LEVEL	F	W	WT FROM TANK.	FT FROM TANK	F-FT
214	86.85+49.7= 136.6	655	498.9	$\frac{499}{655}(136.6)=104$	32.6
169	45.9	440	268.6	28	17.9
146	22.5	246	86	7.9	14.6
125	TOTAL 27.45	353	244.5	19.	8.45
"	PRESSURANT TANK		90	7	
"	RESIDUAL.		18.5		1.45.

TRANSVERSE TANK LOADS SPLIT: LO₂ TANK: 65% - EL 214
35% - EL 169
FUEL TANK: 26% - EL 147
74% - EL 125

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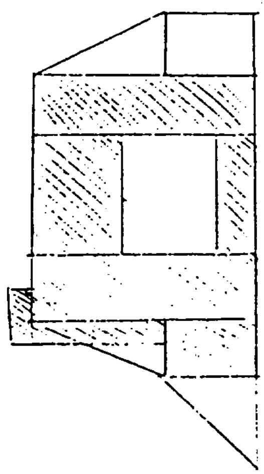
DERIVED LOADS - LIVE

TAKEN AS 100 LB/FT² FROM DRG. SET P.T-S26, & ASSUMED TO INCLUDE ADEQUATE COVERAGE FOR SNOW & ICE LOADS.

ELEV 214:

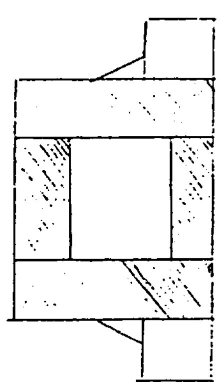


AREA:

39 × 12.63	=	492.6
20.75 × 12.5	=	259.4
20.75 × 6.17	=	128.0
39 × 12.63	=	492.6
16 × 14	=	224.0
5 × 25	=	125.0
5 × 10	=	50.0
		1771.6

1771.6 × ~~106~~ 100 = ~~187,790~~ 177,168 LB.

ELEV 146:



AREA:

39 × 13.5	=	526.5
19 × 13.2	=	250.8
19 × 6.8	=	129.2
39 × 13.5	=	526.5
		1433

1433 × ~~106~~ 100 = ~~151,900~~ 143,300 LB.

$$\boxed{\text{SAY } 178{,}000 \text{ LB.} \quad 144{,}000 \text{ LB.}}$$

DERIVED LOADS – WIND.

WIND LOADS WERE TAKEN FROM SECTION 6 OF WYLE LABS LOADS DOCUMENT, AS FOLLOWS:

REF P.50:

WIND LOAD (KIPS).

LEVEL	N–S	E–W
RS	38	36
146	40	38
169	63	60
214	60	58
	201	192.

REF PAGES 40 & 42:

	N–S.	E–W
TOTAL AREA	4675	5197.
TANK AREA	1454	1454
TANK/TOTAL	.311	.28.

N-S TANK LOAD = .311(201) = 62.5
E-W " = .28(192) = 53.8

TAKING 1) RAD LOAD AS 5/8 FROM UPPER TANK & 3/8 FROM LOWER
2) LO2 TANK DISTRIBUTION AS 65% – UPPER SUPPORT
35% – LOWER SUPPORT
FUEL TANK DISTRIBUTION AS 26% – UPPER SUPPORT
74% – LOWER SUPPORT

GIVES:

LEVEL	N–S				E–W			
	TANKS.			REST.	TANKS			REST
214	62.5	39	25.3	34.7	53.8	33.6	21.8	36.2
169			13.6	49.4			11.8	48.2
146		23.5	6.1	33.9		20.2	5.2	32.8
125			17.4	20.6			15.0	2[illegible]

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Derived Loads - Piping

PIPING & MISCELLANEOUS WTS (REF. WYLE NOTES)

TANK	ITEM		WT (LB)	LEVEL	REF. PAGE
RP-1	FUEL LINES	12 ø x 20'	4500	125'	24.
		6 ø x 20'	563		
		14 ø x 20'	6000		
		10.75 ø x 20	428		
	PIPEX	20 ø x 20	4840		
	4", 6", 8" PIPEX, TUBING, ELEC. & MISC.		6244		
			Σ = 22,575		
	FUEL LINES	6 ø x 35'	2100	146'	25
		10.75 ø x 35'	665		
		12 ø x 10'	2166		
		12 ø x 10'	2250		
		6 ø x 10'	281		
		14 ø x 10'	3000		
		10.75 ø x 10'	214.		
	PIPEX 20 ø x 10'		2420		
	14 ø x 10'		1220		
	MISC.		6684.		
			Σ = 21,000		
LO2	FUEL LINES	12 ø x 30'	6500	168'	26
		14 ø x 30'	3660		
		MISC	7067		
			Σ = 17230		
	FUEL LINES	12 ø x 35'	7000	214'	27.
		12 ø x 20'	4333		
	PIPEX	14 ø x 20'	2440		
	MISC.		6454		
			Σ = 20,227		
		Σ	81,032		

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MICHOUD OPERATIONS

JC DATE 3/30 SUBJECT PFBTS SHEET ____ OF 6-5

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APPROVED ______ DATE ______

APPROVED ______ DATE ______ REV ______ DATE ______

DERIVED LOADS - SUMMARY

PRESSURANT BOTTLE : PER PRED HOUTE : 80,000 LB EMPTY
6,000 LB He
86,000 LB.

REF. ED PHILLIPS: USE 90,000 LB.

REF. ED: USE 90,000 LB FOR TOTAL PIPING, ETC. I.E.

LEVEL	WT (KIPS)
125'	25
146'	23
169'	19
214'	23

REF WYLE NOTES. RP1 TANK WT (TANK + PROPELLANT) = 330,425 LB
LO2 TANK WT (" + ") = 767.546 LB

Summary.

1) VERTICAL LOADS TO APPLY ARE:-

ITEM	VALUE (KIP)	LEVEL	COMMENTS
LO2 TANK	767.5	169'	SUPPORTED AT 4 TRUSS POINTS.
RP1 TANK	330.5	125'	" " "
PIPING ETC	25	125'	ASSUME AT 4 TRUSS POINTS
	23	~~146'~~	"
	19	169'	"
	23	~~214'~~	"
LIVE LOADS	178.0	214'.	DISTRIBUTED OVER PLATFORM
	144.0	146'	" " "
PRESS BOTTLE	90.0	125' ~~146'~~	MAY ALSO BE TRIED ON OTHER LEVELS. PLAN VIEW POSITION TO BE DECIDED (-)

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MICHOUD OPERATIONS

VC DATE 3/30 SUBJECT PFBTS SHEET ____ OF 6-6

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APPROVED ____ DATE ____ REV ____ DATE ____

DERIVED LOADS – DEAD (W/O TANKS)

WYLE NOTES GIVE STEELWORK WT = 594.2^{K}.
MODEL GIVES 438.2^{K}

TO BRING MODEL IN LINE, INTRODUCE COMPENSATING FACTOR OF 594/438 = 1.356.

FORM MAF/MMA 35-016-04/74
NASA-MSFC-MAF

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LOADING SUMMARY

FOLLOWING SHEETS SUMMARIZE THE LOADING APPLIED TO THE MODEL, BASED ON THE FOREGOING DATA.

THE FILE 'STAND' CONTAINS 10 LOADCASES, IE:-

1		E-W	PRESS BOTTLE
2	WIND	W-E.	AT EL 125
3		N-S	
4		S-N.	
5		E-W	
6	SEISMIC.	W-E	PRESS BOTTLE
7		N-S	AT EL 125
8		S-N.	
9	SEISMIC	W-E	BOTTLE AT EL 169
10		W-E	BOTTLE AT EL 214.

RUNS 9 & 10 WERE SET-UP TO GAIN AN INDICATION OF THE EFFECT OF MOUNTING THE PRESS BOTTLE AT EL 169 & 214. THE BOTTLE VERTICAL LOADS WERE TRANSFERRED TO THE 2 ELEVATIONS, BUT THE OVERALL SEISMIC LOADSET WAS NOT ALTERED TO REFLECT THE BOTTLE MASS TRANSFER TO THE 2 LOCATIONS.

ALL RUNS REFLECT 'TANK FULL' CONDITIONS & INCLUDE 'LIVE' LOADING OF ELEVATIONS 147 & 214.

LO2 TANK LOAD INCLUDES 10% INCREASE INTRODUCED DUE TO DISCUSSION RE POSSIBILITY OF WEIGHT INCREASE DUE TO MIXTURE RATIO CHANGES.

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MICHOUD OPERATIONS

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LOADING SUMMARY - CONT'D

LOADS.

DIRN	ITEM	ELEV	NODE	VALUE (KIPS)	TOTAL.
			313	84.17	
VERT	TANKS	125	314	81.33	331.
			319	84.17	
			320	81.33.	
			730	211.2	
		169	732	211.2	844.8
			734	211.2	
			735	211.2	
	PIPING		313	12	
		125	314	12	48
			319	12	
			320	12	
			730	10.5	
		169	732	10.5	42
			734	10.5	
			735	10.5	
	PRESS		306	22.5	
	TANK	125	309	22.5	90
			321	22.5	
			324	22.5	
	LIVE		502	4.3	
	LOADS	146	503	8.6	144.6
			504	8.6	
			505	4.3	
			506	5.9	
			507	18.3	
			508	11.9	
			509	6.6	
			510	3.1	
			514	4.5	
			515	5.9	
			516	18.3	
			517	11.9	
			518	6.6	
			519	4.3	
			520	8.6	
			521	8.6	
			522	4.3	

ARTIN MARIETTA
"CHOUD OPERATIONS

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Loading Summary (Cont'd)

Loads.

DIR'N.	ITEM	ELEV.	NODE	VALUE (KIPS)	TOTAL	
	LIVE	214	1102	5.47		
VERT.	LOADS		1103	10.94		
(CONT'D)	(CONT'D)		1104	10.94		
			1105	5.47		
			1106	7.5		
			1107	23.2		
			1108	15.1		
			1109	8.4	183.7	
			1112	4.0		
			1115	5.7		
			1118	7.5		
			1119	23.2		
			1120	15.1		
			1121	8.4		
			1122	5.07		
			1123	10.94		
			1124	10.94		
			1125	5.47		
SIDE	WIND	125.	26 NODES	.811/NODE	21	
			313	3.725		FROM TANK
			314	3.725	14.9.	
			319	3.725		
			320	3.725.		
		146	24 NODES	1.37/NODE	32.9.	E/W or W/E.
			525	1.31		FROM TANK.
			526	1.31	5.2	
			527	1.31		
			528	1.31		
		169.	30 NODES	1.61/NODE	48.3.	
			730	2.95		FROM TANK.
			731	2.95	11.8	
			732	2.95		
			733	2.95		
		214.	28 NODES	1.29/NODE	36.1	
			1110	5.45		FROM TANK.
			1111	5.45	21.8	
			1116	5.45		
			1117	5.45		

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LOADING SUMMARY

3.

LOADS

DIRN.	ITEM.	ELEV	NODE	VALUE (KIPS)	TOTAL		
SIDE	WIND	25	26 NODES	.792/NODE	20.6		
	(CONT'D)		313	4.35		FROM TANK	
			314	4.35	17.4		
			319	4.35			
			320	4.35			
		14C	24 NODES	1.41/NODE	33.8	N/S or S/N	
			525	1.525		FROM TANK	
			526	1.525	6.1		
			527	1.525			
			528	1.525			
		169	30 NODES	1.65/NODE	49.5		
			730	3.4		FROM TANK	
			731	3.4	13.6		
			732	3.4			
			733	3.4			
		214	28 NODES	1.24/NODE	34.7		
			1110	6.325		FROM TANK	
			1111	6.325	25.3		
			1116	6.325			
			1117	6.325			
		125.	306	.394		E/W or W/E.	FROM PRESS BOTTLE.
			309	.394			
			321	.394	—		
			324	.394			
			306	.394		N/S. or S/N.	
			309	.394	—		
			321	.394			
			324.	.394.			
			306	.388		S/N	
			309	.388		N/S	
			321	.388		E/W	
			324	.388		W/E.	

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MARTIN MARIETTA
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LOADING SUMMARY

4.

LOADS

DIR'N	ITEM	ELEV.	NODE	VALUE (KIPS)	TOTAL		
SIDE	SEISMIC	125	26 NODES	.054/NODE	1.4		
			306	4.75			
			309	4.75	19	FROM	
			321	4.75		TANK E/W	
			324	4.75			
		146	24 NODES	.604/NODE	14.5	W/E	
			525	1.375			
			526	1.375	5.5	FROM N/S	
			527	1.375		TANK	
			528	1.375		S/N	
		169	30 NODES	.597/NODE	17.9		
			730	7		FROM	
			731	7	28	TANK	
			732	7			
			733	7			
		214	28 NODES	1.17/NODE	32.8		
			1110	25.375			
			1111	25.375	103.5	FROM	
			1116	25.375		TANK	
			1117	25.375			
		125	306	1.78			
			309	1.78		E/W	
			321	1.78	—	OR W/E	
			324	1.78			FROM
			306	1.78			PRESS
			309	1.78		N/S	BOTTLE
			321	1.78	—	OR S/N	
			324	1.78			
			306	1.75		N/S	
			309	1.75	7	S/N	
			321	1.75		E/W	
			324	1.75		W/E	

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PROGRAM & DATA KEY

The following datasets and programs were developed and used in the analysis and may be used to obtain any desired output:

STAND.DAT

Contains the model bulk input and loadset, produces standard NASTRAN output data and writes geometry and selected results to unit 20, as requested by the DMAP ALTER statement included in the executive control deck.

SECT.DAT

Contains the section property input data required by STAND.DAT and the stress program.

POST

This FORTRAN program runs a stress analysis on the model elements.

Input - NASTRAN output on unit 20.
SECT.DAT

Output - Units 22,23,24

Unit 22 - Stress ratio list and partial data for all elements and load cases.
Unit 23 - Condensed list of stress ratios for all I-beams and all load cases.
Unit 24 - Condensed list of stress ratios for all back-to-back angle sections and all load cases.

SELECT

This FORTRAN program selects the numerically maximum value in each column of NASTRAN unit 20 output (i.e. internal loads) over the range of cases considered.

1) For each element.

Input - NASTRAN output on unit 20.

Output - OUTPUT.DAT

2) Optionally, for selected elements.

Input - (Filename)

Output - unit 8, unit 9 (unit 9 = tabular format for MACINTOSH applications.)

Contents of optional file:

a,b,c

where: a = first element, b = final element, c = step

e.g. 213,215,1 gives elements 213,214,215,100,105,110.
100,110,5

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STRESS PROGRAM

THE PROGRAM 'POST' CARRIES OUT THE ANALYSIS MARKED ON THE FOLLOWING SHEETS (REF. 'MANUAL OF STEEL CONSTRUCTION - 7TH. ED.') & PRODUCES THE FOLLOWING OUTPUT FILES:

FOR022.DAT - LIST OF STRESS RATIOS & PARTIAL DATA FOR ALL MEMBERS

FOR023.DAT - SUMMARY STRESS RATIO LIST FOR I-BEAMS

FOR024.DAT - SUMMARY STRESS RATIO LIST FOR TT BEAMS.

1.5.2.2 Allowable bearing stress on projected area of bolts in bearing-type connections and on rivets:

$$F_p = 1.35F_y$$

where F_y is the yield stress of the connected part. (Bearing stress is not restricted in friction-type connections assembled with A325, A449 or A490 bolts.)

1.5.3 Welds

Except as modified by the provisions of Sect. 1.7, welds shall be proportioned to meet the stress requirements given in Table 1.5.3.

1.5.4 Cast Steel and Steel Forgings

Allowable stresses same as those provided in Sect. 1.5.1, where applicable.

1.5.5 Masonry Bearing

In the absence of Code regulations the following stresses apply:

On sandstone and limestone.	$F_p = 0.40$ ksi
On brick in cement mortar	$F_p = 0.25$ ksi
On the full area of a concrete support	$F_p = 0.25f'_c$
On one-third of this area	$F_p = 0.375f'_c$

where f'_c is the specified compression strength of the concrete.

1.5.6 Wind and Seismic Stresses

Allowable stresses may be increased one-third above the values provided in Sect. 1.5.1 1.5.2, 1.5.3, 1.5.4 and 1.5.5 when produced by wind or seismic loading, acting alone or in combination with the design dead and live loads, provided the required section computed on this basis is not less than that required for the design dead and live load and impact (if any), computed without the one-third stress increase.

SECTION 1.6 COMBINED STRESSES

1.6.1 Axial Compression and Bending

Members subjected to both axial compression and bending stresses shall be proportioned to satisfy the following requirements:

$$\frac{f_a}{F_a} + \frac{C_{mx}f_{bx}}{\left(1 - \frac{f_a}{F'_{ex}}\right)F_{bx}} + \frac{C_{my}f_{by}}{\left(1 - \frac{f_a}{F'_{ey}}\right)F_{by}} \leqslant 1.0 \qquad (1.6\text{-}1a)$$

$$\frac{f_a}{0.60F_y} + \frac{f_{bx}}{F_{bx}} + \frac{f_{by}}{F_{by}} \leqslant 1.0 \qquad (1.6\text{-}1b)$$

When $\frac{f_a}{F_a} \leqslant 0.15$, Formula (1.6-2) may be used in lieu of Formulas (1.6-1a) and (1.6-1b)

$$\frac{f_a}{F_a} + \frac{f_{bx}}{F_{bx}} + \frac{f_{by}}{F_{by}} \leqslant 1.0 \qquad (1.6\text{-}2)$$

In Formulas (1.6-1a), (1.6-
combined with subscripts b, m
which a particular stress or desig

F_a = axial stress that would

F_b = compressive bending
moment alone exist

$F'_e = \frac{12\pi^2E}{23(Kl_b/r_b)^2}$ (In the e
length *in*
sponding
length fa
of F_a, F_b
in accord

f_a = computed axial stress

f_b = computed compressiv
sideration

C_m = a coefficient whose val

1. For compression me
(sidesway), C_m = 0.
2. For restrained comp
joint translation and
their supports in the

$C_m = 0.6 - 0.4$

where M_1/M_2 is the
the ends of that port
bending under con
member is bent in re
in single curvature.

3. For compression me
lation in the plane o
ing between their su
by rational analysis
following values ma
are restrained, C_m =
unrestrained, C_m =

1.6.2 Axial Tension and Bend

Members subject to both a
proportioned at all points along t
Formula (1.6-1b) where f_b is the co
the computed bending compress
the applicable value according to

1.6.3 Shear and Tension

Rivets and bolts subject to
proportioned that the tension st
forces applied to the connected p

9-3

ected area of bolts in bearing-

rt. (Bearing stress is not re-
d with A325, A449 or A490

Sect. 1.7, welds shall be pro-
n in Table 1.5.3.

n Sect. 1.5.1, where applicable.

llowing stresses apply:

. . . . $F_p = 0.40$ ksi
. . . . $F_p = 0.25$ ksi
. . . . $F_p = 0.25f'_c$
. . . . $F_p = 0.375f'_c$

f the concrete.

above the values provided
oduced by wind or seismic
e design dead and live loads,
is basis is not less than that
d impact (if any), computed

sion and bending stresses shall
ements:

$\frac{{}_{my}f_{by}}{\left(\frac{f_a}{F'_{ey}}\right) F_{by}} \leqslant 1.0$ (1.6-1a)

$\leqslant 1.0$ (1.6-1b)

be used in lieu of Formulas

1.0 (1.6-2)

In Formulas (1.6-1a), (1.6-1b), and (1.6-2) the subscripts x and y, combined with subscripts b, m and e, indicate the axis of bending about which a particular stress or design property applies, and

F_a = axial stress that would be permitted if axial force alone existed

F_b = compressive bending stress that would be permitted if bending moment alone existed

$F'_e = \dfrac{12\pi^2 E}{23(Kl_b/r_b)^2}$ (In the expression for F'_e, l_b is the actual unbraced length *in the plane of bending* and r_b is the corresponding radius of gyration. K is the effective length factor *in the plane of bending*. As in the case of F_a, F_b and 0.6 F_y, F'_e may be increased one-third in accordance with Sect. 1.5.6.)

f_a = computed axial stress

f_b = computed compressive bending stress at the point under consideration

C_m = a coefficient whose value shall be taken as follows:

1. For compression members in frames subject to joint translation (sidesway), $C_m = 0.85$.
2. For restrained compression members in frames braced against joint translation and not subject to transverse loading between their supports in the plane of bending,

   $$C_m = 0.6 - 0.4\frac{M_1}{M_2}, \text{ but not less than } 0.4,$$

   where M_1/M_2 is the ratio of the smaller to larger moments at the ends of that portion of the member unbraced in the plane of bending under consideration. M_1/M_2 is positive when the member is bent in reverse curvature and negative when it is bent in single curvature.
3. For compression members in frames braced against joint translation in the plane of loading and subjected to transverse loading between their supports, the value of C_m may be determined by rational analysis. However, in lieu of such analysis, the following values may be used: (*a*) for members whose ends are restrained, $C_m = 0.85$; (b) for members whose ends are unrestrained, $C_m = 1.0$.

1.6.2 Axial Tension and Bending

Members subject to both axial tension and bending stresses shall be proportioned at all points along their length to satisfy the requirements of Formula (1.6-1b) where f_b is the computed bending tensile stress. However, the computed bending compressive stress, taken alone, shall not exceed the applicable value according to Sect. 1.5.1.4.

1.6.3 Shear and Tension

Rivets and bolts subject to combined shear and tension shall be so proportioned that the tension stress, in kips per square inch, produced by forces applied to the connected parts, shall not exceed the following:

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	Yield Stress — F_y (ksi)			Yield Stre		
	36.0	42.0	45.0	50.0	55.0	60.0
SECTION 1.5 ALLOWABLE STRESSES						
1.5.1.1 Tension						
Tension on the net section, except at pin holes: $F_t = 0.60F_y \leq 0.50F_{TS}$ where F_{TS} = minimum tensile strength	22.0	25.2	27.0	30.0	33.0	36.0
Tension on the net section at pin holes in eyebars, pin-connected plates or built-up members: $F_t = 0.45F_y$	16.2	19.0	20.3	22.5	24.8	27.0
1.5.1.2 Shear						
Shear on the gross section (see Table 3 for reduced values for girder webs): $F_v = 0.40F_y$	14.5	17.0	18.0	20.0	22.0	24.0
1.5.1.3 Compression						
1.5.1.3.1 Compression on the gross section of axially loaded compression members when Kl/r is less than C_c: Formula (1.5-1) $F_a = \dfrac{\left[1 - \dfrac{(Kl/r)^2}{2C_c^2}\right]F_y}{\dfrac{5}{3} + \dfrac{3(Kl/r)}{8C_c} - \dfrac{(Kl/r)^3}{8C_c^3}}$	Table 1-36	Table 1-42	Table 1-45	Table 1-50	Table 1-55	Table 1-60
1.5.1.3.2 Compression on the gross section of axially loaded compression members when Kl/r exceeds C_c: Formula (1.5-2) $F_a = \dfrac{12\pi^2E}{23(Kl/r)^2}$	Table 1-36	Table 1-42	Table 1-45	Table 1-50	Table 1-55	Table 1-60
1.5.1.3.3 Compression on the gross section of axially loaded bracing and secondary members when l/r exceeds 120: Formula (1.5-3) $F_{as} = \dfrac{F_a \text{ [by Formula (1.5-1) or (1.5-2)]}}{1.6 - \dfrac{l}{200r}}$	Table 1-36	Table 1-42	Table 1-45	Table 1-50	Table 1-55	Table 1-60

* Value equal to 0.50 times minimum tensile strength ($= 0.50F_{TS}$)

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	Yield Stress — F_y (ksi)					
	36.0	42.0	45.0	50.0	55.0	60.0
1.5.1.3 Compression (cont'd)						
1.5.1.3.4 Compression on the gross area of plate girder stiffeners: $F_a = 0.60F_y$	22.0	25.2	27.0	30.0	33.0	36.0
1.5.1.3.5 Compression on the web of rolled shapes at the toe of fillet: $F_a = 0.75F_y$	27.0	31.5	33.8	37.5	41.3	45.0
1.5.1.4 Bending						
1.5.1.4.1 Tension and compression for compact, adequately braced members symmetrical about, and loaded in, the plane of their minor axis: $F_b = 0.66F_y$	24.0	28.0	29.7	33.0	36.3	39.6
when a. Flanges are continuously connected to web						
b. $b_f/2t_f \leq 52.2/\sqrt{F_y}$	8.7	8.1	7.8	7.4	7.0	6.7
c. $b/t_f \leq 190/\sqrt{F_y}$	31.7	29.3	28.3	26.9	25.6	24.5
d. Use Formula (1.5-4): $d/t \leq 412\left(1 - 2.33\frac{f_a}{F_y}\right)\Big/\sqrt{F_y}$	$68.7 - 4.4f_a$	$63.6 - 3.5f_a$	$61.4 - 3.2f_a$	$58.3 - 2.7f_a$	$55.6 - 2.4f_a$	$53.2 - 2.1f_a$
except that d/t need not be less than $257/\sqrt{F_y}$	42.8	39.7	38.3	36.3	34.7	33.2
e. $l \leq 76.0b_f/\sqrt{F_y}$	$12.7b_f$	$11.7b_f$	$11.3b_f$	$10.7b_f$	$10.2b_f$	$9.8b_f$
and $l \leq \frac{20,000}{(d/A_f)F_y}$	$\frac{556}{d/A_f}$	$\frac{476}{d/A_f}$	$\frac{444}{d/A_f}$	$\frac{400}{d/A_f}$	$\frac{364}{d/A_f}$	$\frac{333}{d/A_f}$

		Yield Stress — F_y (ksi)			Yield Stre		
		36.0	42.0	45.0	50.0	55.0	60.0
1.5.1.4 Bending (cont'd)							
1.5.1.4.2 Tension and compression for members which meet the requirements of Sect. 1.5.1.4.1 except subparagraph b:							
when $\frac{52.2}{\sqrt{F_y}} < \frac{b_f}{2t_f}$		8.7	8.1	7.8	7.4	7.0	6.7
and $\frac{b_f}{2t_f} < \frac{95.0}{\sqrt{F_y}}$		15.8	14.7	14.2	13.4	12.8	12.3
use Formula (1.5-5): $F_b = F_y\left[0.733 - 0.0014\left(\frac{b_f}{2t_f}\right)\sqrt{F_y}\right]$	$\frac{b_f}{2t_f}$						
Values of F_b	7.0	—	—	—	—	—	39.4
	8.0	—	—	29.6	32.7	35.7	38.8
	9.0	23.7	27.3	29.2	32.2	35.2	38.1
	10.0	23.4	27.0	28.8	31.7	34.6	37.5
	11.0	23.1	26.6	28.4	31.2	34.0	36.8
	12.0	22.8	26.2	27.9	30.7	33.5	36.2
	13.0	22.5	25.8	27.5	30.2	—	—
	14.0	22.1	25.5	27.1	—	—	—
	15.0	22.0	—	—	—	—	—
1.5.1.4.3 Tension and compression for: doubly-symmetrical I and H shape members meeting the requirements of Sect. 1.5.1.4.1, except subparagraphs c, d and e, and bent about their minor axis (except members of A514 steel); solid round and square bars; and solid rectangular bars bent about their weaker axis:							
$F_b = 0.75F_y$		27.0	31.5	33.8	37.5	41.3	45.0
1.5.1.4.4 Tension and compression for box-type flexural members not included in Sect. 1.5.1.4.1, but which meet the requirements of Sect. 1.9:							
$F_b = 0.60F_y$		22.0	25.2	27.0	30.0	33.0	36.0
when $l \leq 2500b/F_y$		69.4b	59.5b	55.6b	50.0b	45.5b	41.7b

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	Yield Stress — F_y (ksi)					
	36.0	42.0	45.0	50.0	55.0	60.0
1.5.1.4 Bending (cont'd)						
1.5.1.4.5 Tension for flexural members not covered in Sect. 1.5.1.4.1, 1.5.1.4.2, 1.5.1.4.3 or 1.5.1.4.4: $F_b = 0.60F_y$	22.0	25.2	27.0	30.0	33.0	36.0
1.5.1.4.6a Compression for flexural members included under Sect. 1.5.1.4.5, having an axis of symmetry in, and loaded in, the plane of their web; compression for channels bent about their major axis: The larger value computed by Formula (1.5-6a) or (1.5-6b) and Formula (1.5-7), but not more than $F_b = 0.60F_y$	22.0	25.2	27.0	30.0	33.0	36.0
when $l/r_T \le \sqrt{\dfrac{102 \times 10^3 \times C_b}{F_y}}$ *	$53\sqrt{C_b}$	$49\sqrt{C_b}$	$48\sqrt{C_b}$	$45\sqrt{C_b}$	$43\sqrt{C_b}$	$41\sqrt{C_b}$
When this limit is exceeded, use Formula (1.5-6a): $F_b = \left[\dfrac{2}{3} - \dfrac{F_y(l/r_T)^2}{1{,}530 \times 10^3 \times C_b}\right] F_y$ *	$24.0 - \dfrac{(l/r_T)^2}{1181C_b}$	$28.0 - \dfrac{(l/r_T)^2}{867C_b}$	$30.0 - \dfrac{(l/r_T)^2}{756C_b}$	$33.3 - \dfrac{(l/r_T)^2}{612C_b}$	$36.7 - \dfrac{(l/r_T)^2}{506C_b}$	$40.0 - \dfrac{(l/r_T)^2}{425C_b}$
unless $l/r_T \ge \sqrt{\dfrac{510 \times 10^3 \times C_b}{F_y}}$ *	$119\sqrt{C_b}$	$110\sqrt{C_b}$	$106\sqrt{C_b}$	$101\sqrt{C_b}$	$96\sqrt{C_b}$	$92\sqrt{C_b}$
in which case, use Formula (1.5-6b): $F_b = \dfrac{170 \times 10^3 \times C_b}{(l/r_T)^2}$ *						
When the compression flange is solid and approximately rectangular in cross-section and its area is not less than that of the tension flange, use Formula (1.5-7): $F_b = \dfrac{12 \times 10^3 \times C_b}{ld/A_f}$ *						

*For values of C_b see Fig. A1, p. 5-104.

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	Yield Stress — F_y (ksi)			Yield St		
	36.0	42.0	45.0	50.0	55.0	60.0
1.5.1.4. Bending (cont'd)						
1.5.1.4.6b Compression for flexural members included under Sect. 1.5.1.4.5, which do not satisfy the requirements of Sect. 1.5.1.4.6a, and which if bent about their major axis are braced so that $l \leq (76.0b_f/\sqrt{F_y})$ $F_b = 0.60F_y$	$12.7b_f$ 22.0	$11.7b_f$ 25.2	$11.3b_f$ 27.0	$10.7b_f$ 30.0	$10.2b_f$ 33.0	$9.8b_f$ 36.0
1.5.1.5 Bearing (on contact area)						
1.5.1.5.1 Bearing on milled surfaces, including bearing stiffeners and pins in reamed, drilled, or bored holes: $F_p = 0.90F_y$	33.0	38.0	40.5	45.0	49.5	54.0
1.5.1.5.2 Bearing on expansion rollers and rockers: $F_p = \left(\frac{F_y - 13}{20}\right) 0.66d$	$0.76d$	$0.96d$	$1.06d$	$1.22d$	$1.39d$	$1.55d$
1.5.2 Rivets, Bolts, and Threaded Parts						
1.5.2.2 Bearing on projected area of bolts in bearing-type connections and on rivets: $F_p = 1.35F_y$	48.6	56.7	60.8	67.5	74.3	81.0
SECTION 1.9 WIDTH-THICKNESS RATIOS						
1.9.1 Unstiffened Elements Under Compression						
1.9.1.2 Maximum width-to-thickness ratios for unstiffened elements of: Single-angle struts; double-angle struts with separators: $76.0/\sqrt{F_y}$	12.7	11.7	11.3	10.7	10.2	9.8
Double-angle struts in contact; angles or plates projecting from girders, columns or other compression members, compression flanges of beams; stiffeners on plate girders: $95.0/\sqrt{F_y}$	15.8	14.7	14.2	13.4	12.8	12.3
Stems of tees: $127/\sqrt{F_y}$	21.2	19.6	18.9	18.0	17.1	16.4

SECTION PROPERTY DATA

SECTIONS USED IN THE MODEL ARE LISTED ON THE FOLLOWING SHEETS & CODED ACCORDING TO THE CIRCLED NUMBERS. CODED DATA IS AS TABULATED.

THE DATA IS CONTAINED IN THE FILE 'SECT.DAT' WHICH IS CALLED UP BY THE APPROPRIATE PROGRAMS

MARTIN MARIETTA
MICHOUD OPERATIONS

JC DATE 3/30 SUBJECT PFBTS SHEET ____ OF 10-2

WORK PACKAGE ____

APPROVED ____ DATE ____

APPROVED ____ DATE ____ REV ____ DATE ____

MATH MODEL
SECTION PROP CARDS

	SECTION		A	Ix	Iy	J	DEPTH	WIDTH	Δ
1	36 WF	194	57.2	12,100	375	21.33	36.48	12.12	.24
2	24	160	47.1	5120	530	15.85	24.72	14.09	.36
3		130	38.3	4020	412	8.15	24.25	14.00	.12
4		100	29.5	3000	223	4.49	24.00	12.00	0
5		94	27.7	2690	108	5.04	24.29	9.06	.15
6		76	22.4	2100	82.6	2.54	23.91	8.89	-.05
7	16	50	14.7	657	37.1	1.44	16.25	7.07	.125
8		40	11.8	517	28.8	.739	16.00	7.00	0
9	14	193	56.7	2400	930	34.11	15.50	15.71	.75
10		167	49.1	2020	790	22.21	15.12	15.60	.56
11		142	41.8	1670	660	13.73	14.75	15.50	.375
12		136	40.0	1590	568	13.01	14.75	14.74	.37
13		119	35.0	1370	492	8.84	14.50	14.65	.25
14		78	22.9	851	207	3.29	14.06	12.00	.03
15		68	20.0	724	121	2.78	14.06	10.04	.03
16		61	17.9	641	107	2.00	13.91	10.00	-.05
17		48	14.1	485	51.3	1.28	13.81	8.03	-.10
18		43	12.6	429	45.1	.91	13.68	8.00	-.16
19	12	161	47.4	1540	486	30.07	13.88	12.51	.94
20		99	29.1	859	278	7.07	12.75	12.19	.375
21		92	27.1	789	256	5.67	12.62	12.15	.31
22		85	25.0	723	235	4.51	12.50	12.10	.25
23		79	23.2	663	216	3.59	12.38	12.08	.19
24		72	21.2	597	195	2.71	12.25	12.04	.12
25		65	19.1	533	175	2.00	12.12	12.00	.06
26		53	15.6	426	96.1	1.42	12.06	10.00	.03
27		50	14.7	395	56.4	1.60	12.19	8.08	.10
28		40	11.8	310	44.1	.825	11.94	8.00	-.03
29		27	7.95	204	18.3	.327	11.96	6.50	-.02
30		24							
31	8	24	7.06	82.5	18.2	.308	7.93	6.50	-.09
32	6B16		4.72	31.7	4.32	.169	6.25	4.00	

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MARTIN MARIETTA
MICHOUD OPERATIONS

JC DATE 3/30 SUBJECT PFBTS

SHEET ___ OF 10-3

WORK PACKAGE

APPROVED ___ DATE ___

APPROVED ___ DATE ___ REV ___ DATE ___

				J	A	I_1	I_2	y/N	A	I_1	I_2	J	W/2	Y/2
50	6	8	3/4	2.56	19.87	126.8	122.9	1.56		61.4	258	3.726	6.19	5.44
51	6	8	1/2	2.47	13.5	88.6	86.5	1.47		43.4	171.1	1.125	6.19	5.53
52	6	8	7/16	2.45	11.87	78.4	70.3	1.45		38.5	149.6	.757	6.19	5.55
53	4	7	3/8	2.37	7.97	49.2	10.1	.87		10.2	85.9	.409	4.19	4.63
54	4	6	1/4	2.08	13.575	49.1	39.7	1.08		17.4	108.9	2.002	4.19	3.92
55	4	6	1/8	1.94	7.22	26.9	19.0	.94		9.8	54.1	.338	4.19	4.06
56	3½	6	5/16	2.01	5.74	21.8	16.9	.76		5.7	45.1	.187	3.69	3.99
57	3½	5	3/8	1.61	6.1	15.6	13.6	.86		6.4	31.4	.286	3.69	3.39
58	3½	5	5/16	1.59	5.1	13.2	10.8	.84		5.4	26.1	.167	3.69	3.41
59	3	5	5/16	1.68	4.8	12.5	7.10	.68		3.49	26.1	.156	3.19	3.32
60	3	4	1/4	1.24	3.37	5.54	5.61	.74		2.71	10.7	.0703	3.19	2.76
61	2½	3½	1/4	1.11	2.87	3.60	3.77	.61		1.55	7.17	.060	2.69	2.79
62	2½	3	1/4	.91	2.62	2.35	3.77	.66		1.49	4.52	.0547	2.69	2.09
63	2½	2½	1/4	.72	2.37	1.41	2.71					.0495	2.69	1.78
64	2	2½	1/4	.79	2.12	1.31	1.56	.54		.74	2.62	.0413	2.19	1.71
65	6	8	5/8	2.52	16.72	108.2	101.9	1.52		52.66	214.2	2.177	6.19	5.48
66	4	8	5/8	2.91	14.21	93.8	77.3	.91		16.2	213.9	1.851	4.19	5.09

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JC DATE 3/30 SUBJECT PFBTS SHEET ____ OF 10-4

WORK PACKAGE ____

APPROVED ____ DATE ____

APPROVED ____ DATE ____ REV ____ DATE ____

	Section		$\bar{y}$	A	I_1	I_2	$\bar{y}$	W/2	Y/2	J
67	6, 8	7/8	2.61	22.97	144.6	143.84	6.1875	6.187	5.39	5.86
68	4, 7	7/16	2.39	9.24	47.3	9.24	4.17	4.187	4.61	.59
69	6, 8	1	2.65	26.0	161.5	165.7	6.1875	6.187	5.35	8.67

	SECTION	A	I_x	I_y		J	W/2	D/2
33	12 B 16.5	4.86	105.3	2.79	4, 1.269, .43, 12	.295	2	6
34	14 WF 103	30.3	1170	420	14.75, 1.425	5.73	7.288	7.13
35	12 WF 58	17.1	476	107	10.01, 12.19	1.93	5.80	6.09
36	—	62.0	3317	577.2	13, 2, 18	687	6.0	9.0
37	12 B 22	6.47	155.7	4.55	4.03, 12.31	.272	2.01	6.15

RTIN MARIETTA
OUD OPERATIONS

JC DATE 3/30 SUBJECT PFBTS SHEET ____ OF 147

WORK PACKAGE

OVED ____ DATE ____

OVED ____ DATE ____ REV ____ DATE ____

NODE & ELEMENT KEY

IN THE FOLLOW SHEETS,

NODES ARE INDICATED THUS : 123

ELEMENTS ARE INDICATED THUS : $\overline{123}$

ELEMENT TYPES THUS. 53

FOR ELEMENTS;

100 - 149 INDICATES VERTICAL WALL ELEMENTS BELOW EL 115.

200 - 249 " " " BETWEEN 115-125, ETC.

150 - 199 " ELEMENTS ON ELEVATION 115.

250 - 299 " " " " 125, ETC.

MEMBER INDEXES ARE GIVEN 5000 OR 8000 SERIES NUMBERS.

TRUSS ELEMENTS NOT PART OF THE ELEVATIONS OR WALLS
ARE NUMBERED 1-49 FOR TRUSS 115-125.
50-100 " " 157-169.

ELEMENT TYPES ARE 1 TO 49 FOR I-BEAMS
50 TO 100 FOR T MEMBERS

ELEMENT ORIENTATION IS DEFINED ACCORDING TO THE SYSTEM
ON THE FOLLOWING SHEETS.
A TYPE 33 ON AN ELEVATION (I.E. PLAN) ORIENTED AS
A '100 SERIES' WILL APPEAR ON MODEL CODING AS 133,
ETC.

DOUBLE NODES (E.G. 112 1112) ARE JOINED BY RIGID
ELEMENTS, & MODEL AXIS OFFSETS OF ABUTTING ELEMENTS.

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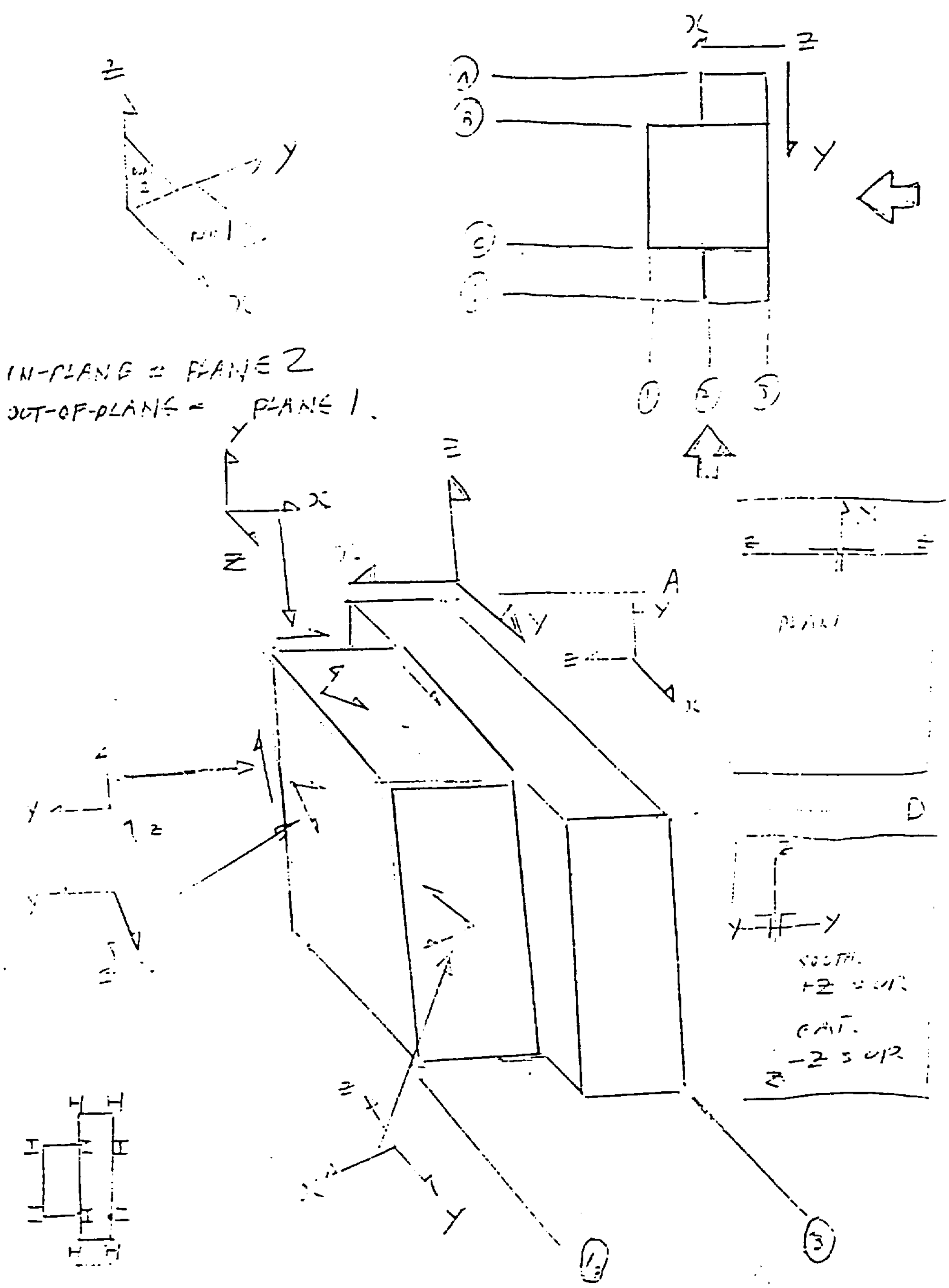
MARTIN MARIETTA
MICHOUD OPERATIONS

VC	DATE 3/30	SUBJECT PFBTS	SHEET ___ OF 142
WORK PACKAGE			
APPROVED	DATE		
APPROVED	DATE	REV	DATE

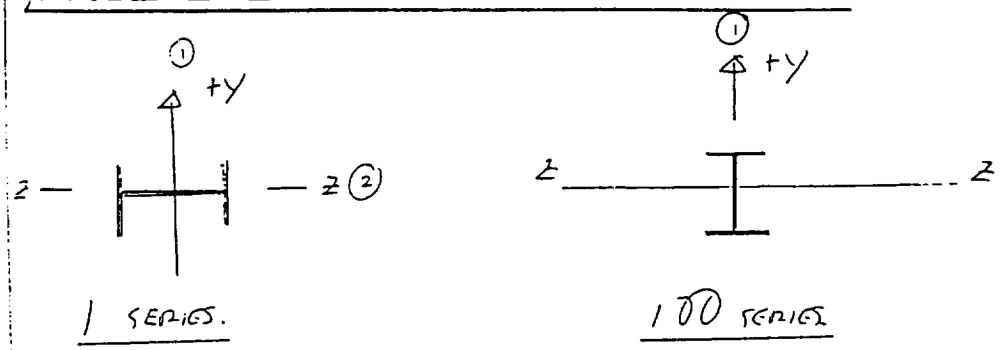
Node & Element Key - Cont'd

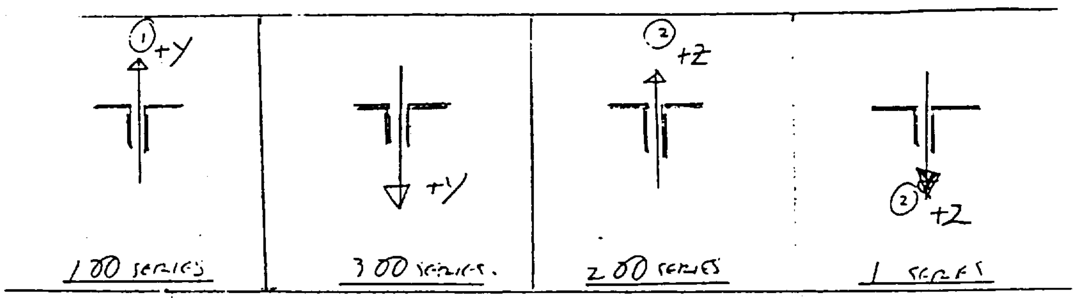


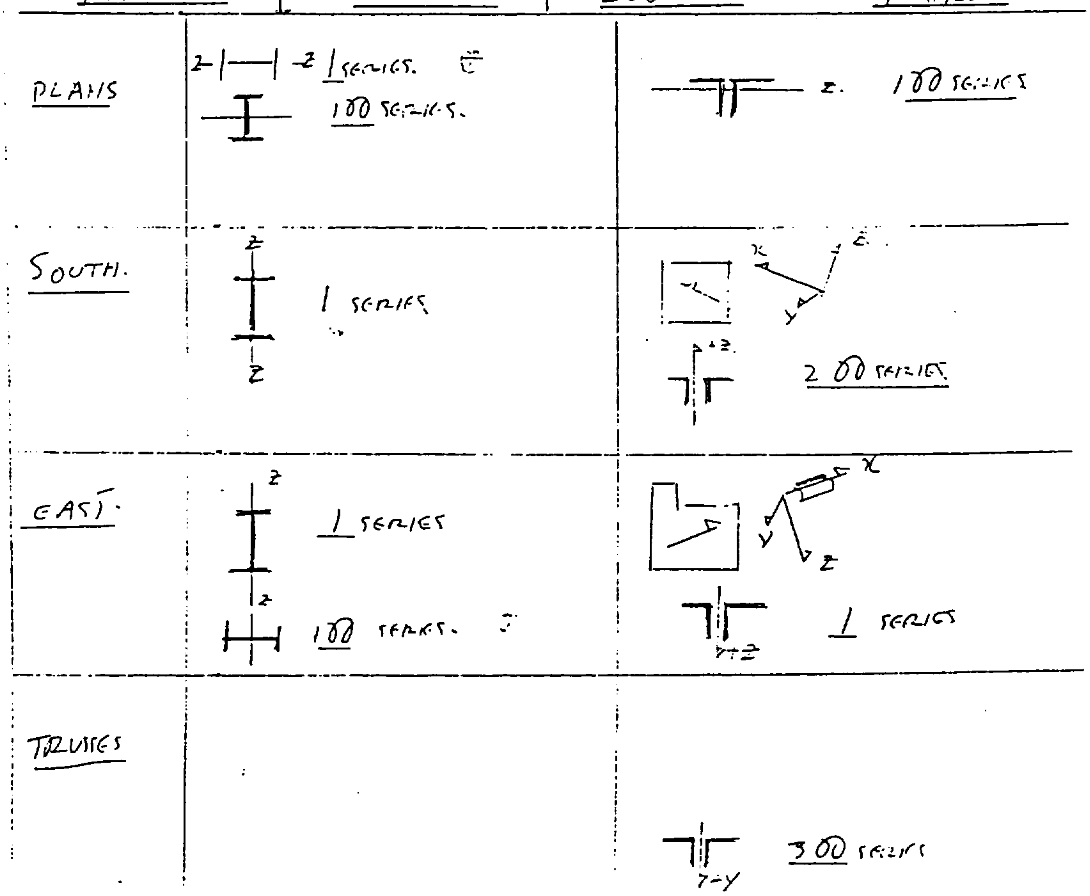
ARTIN MARIETTA
ICHOUD OPERATIONS

JC	DATE 3/30	SUBJECT PFBTS	SHEET ___ OF 11-3
	WORK PACKAGE		
ROVED	DATE		
ROVED	DATE	REV	DATE

NODE & ELEMENT KEY CONT'D







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ARTIN MARIETTA
ICHOUD OPERATIONS

JC DATE 3/30 SUBJECT PFBTS SHEET ____ OF 124

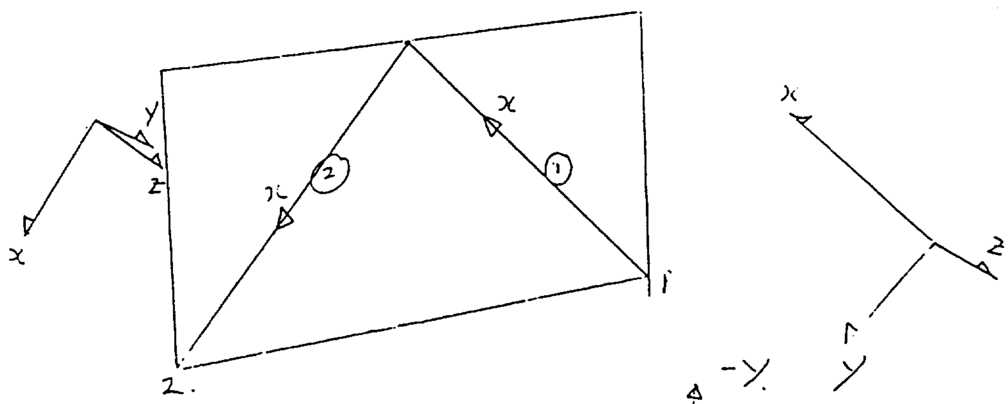
WORK PACKAGE ____

ROVED ____ DATE ____

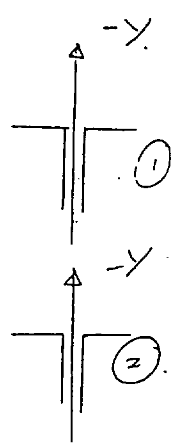
ROVED ____ DATE ____ REV ____ DATE ____

NODE & ELEMENT KEY - CONT'D

TRUSS TRANSVERSE MEMBERS (C, D, E, F) LOCAL AXES DEFINITIONS



ELEMENT	REF NODE
1	2
2	1



ELEMENT	REF NODE	ELEMENT	REF NODE
19	208	69	608
20	2211	70	611
21	208	71	608
22	210	72	610
23	2211	73	611
24	214	74	614
25	210	75	610
26	214	76	614
28	2209	78	607
29	2209	79	607
30	2215	80	613

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ARTIN MARIETTA
CHOUD OPERATIONS

JC DATE 3/30/89 SUBJECT PFBTS. SHEET ____ OF 12-1

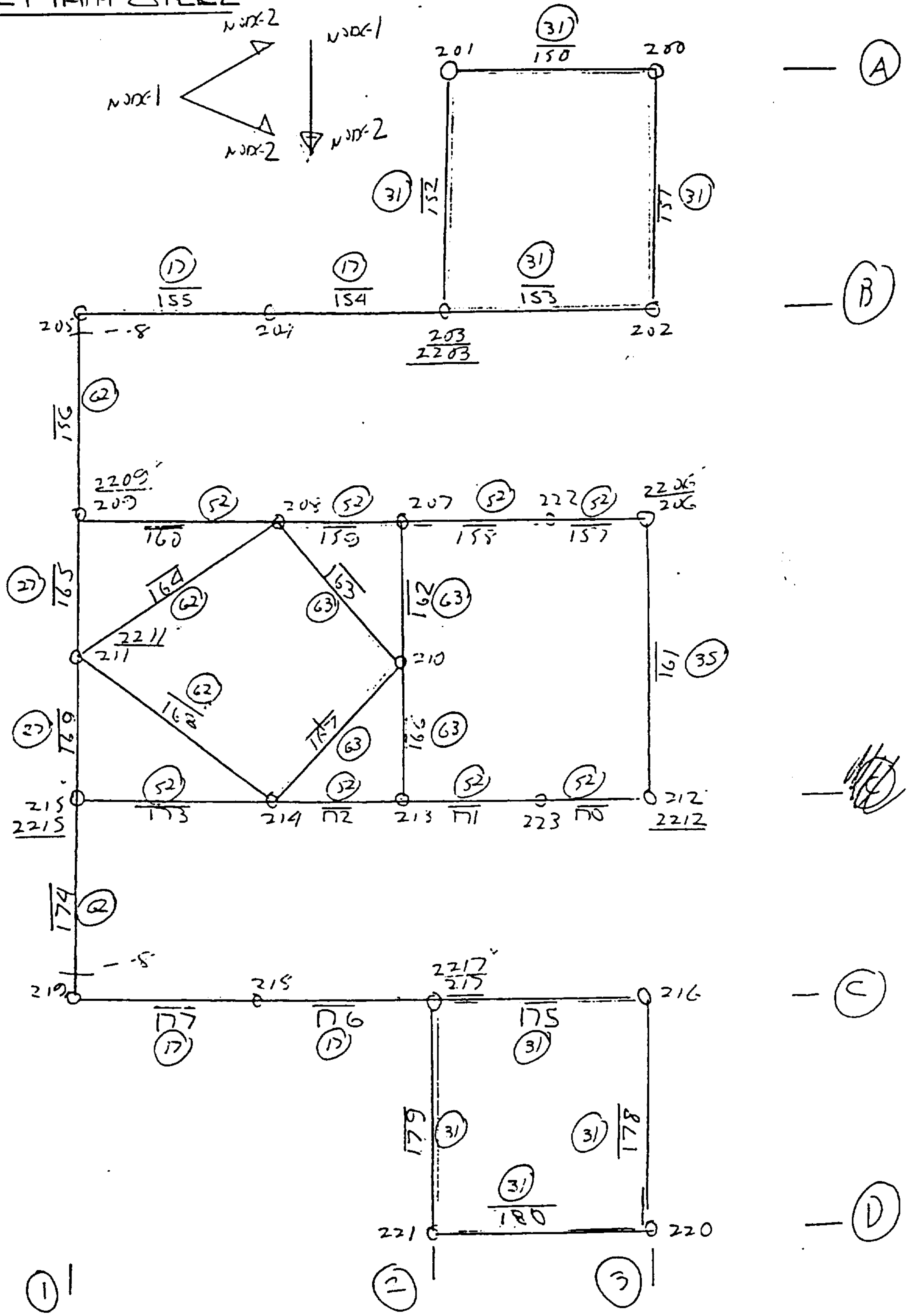
WORK PACKAGE

/ED ______ DATE ______

ROVED ______ DATE ______ REV ______ DATE ______

MATH MODEL – MAIN STEEL

NODE	X	Y	Z_3	Z_5
200	0	0	1379.8	
201	168	0	↓	
202	0	192		
203	168	192	↓	1375.85
204	297	192	1375.85	
205	468	192	↓	
206	0	369	1376.65	1380.25
207	197	369	1380.25	
208	297	369	↓	
209	468	369	1376.65	1380.25
210	197	468	1380.25	
211	468	468	1376.65	1380.25
212	0	567	1376.65	1380.25
213	197	567	1380.25	
214	297	567	1380.25	
215	468	567	1376.65	1380.25
216	0	744	1379.3	
217	168	744	1379.3	1380.25
218	297	744	1376.65	
219	468	744	1380.25	
220	0	936	1379.3	
221	168	936	1379.3	
222	98	369	1380.25	
223	98	567	1380.25	



ELEV 115

MARTIN MARIETTA
MICHOUD OPERATIONS

SHEET ____ OF 12-2

JC DATE 3/30 SUBJECT PFBTS

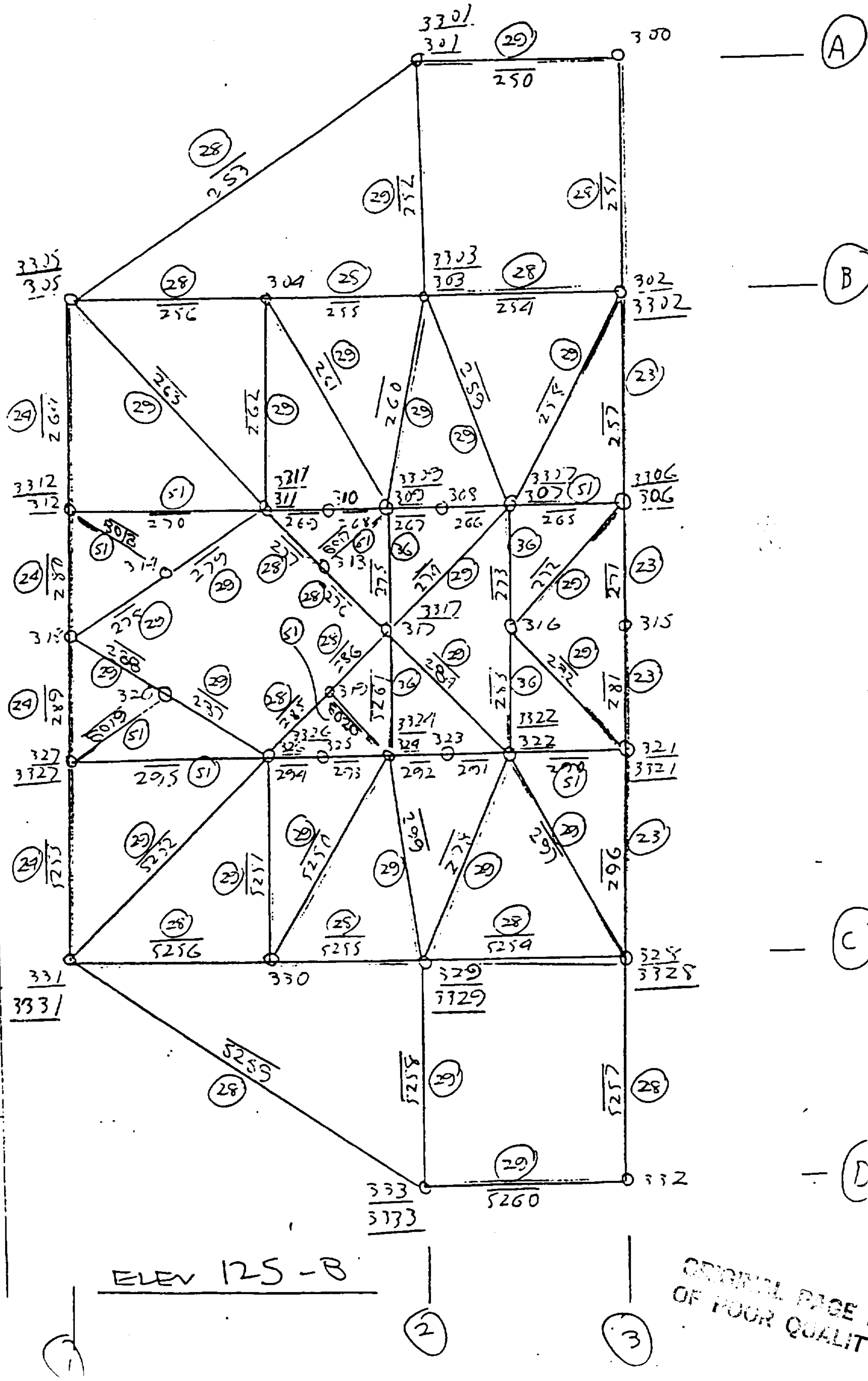
WORK PACKAGE ____

____ DATE ____

____ DATE ____ REV ____ DATE ____

MATH MODEL - MAIN STEEL

NOD	X	Y	Z_3	Z_4
300	[illegible]	0	1501.8	
301	1[illegible]8	0	1501.8	1500.8
302	0	192	1501.8	1500.6
303	16[illegible]	192	1501.8	1500.8
304	297	192	1500.8	
305	468	192	1500.8	1500.6
306	0	[illegible]	1501.3	1500.6
307	98	[illegible]	1501.3	1500.8
308	156	[illegible]	1501.3	
309	197	[illegible]9	1501.3	1500.8
310	238	[illegible]	1501.3	
311	297	3[illegible]	1501.3	1500.8
312	468	3[illegible]	1501.3	1500.6
~~313~~	~~297~~	~~[illegible]~~	~~1500.8~~	
~~314~~	~~355~~	~~4[illegible]~~	~~1500.8~~	
315	0	46[illegible]	1500.6	
316	[illegible]	46[illegible]	1500.8	
317	197	46[illegible]	1497.8	1500.8
318	468	468	1500.6	
~~319~~	~~297~~	~~517.5~~	~~1500.8~~	
~~320~~	~~355~~	~~[illegible]~~	~~1500.8~~	
321	0	567	1501.3	1500.6
322	[illegible]	567	1501.3	1500.8
323	156	567	1501.3	
324	1[illegible]	567	1501.3	1500.8
325	238	567	1501.3	
326	297	567	1501.3	1500.8
327	468	567	1501.3	1500.6
328	0	744	1501.3	1500.6
329	168	744	1501.3	1500.8
330	297	744	1500.8	
331	468	744	1500.8	1500.6
332	0	936	1501.3	
333	168	936	1501.3	1500.8
313	253.93	411.[illegible]	1500.8	
314	349.4[illegible]	39[illegible]	1500.8	
319	253.[illegible]	524.[illegible]	1500.8	
320	34[illegible]	53[illegible]	1500.8	



ELEV 125-B

FORM MAF/MMA 35-016-04/74
NASA-MSFC-MAF

ARTIN MARIETTA
MICHOUD OPERATIONS

SHEET ____ OF 12-3

JC DATE 3/30 SUBJECT PFBTS

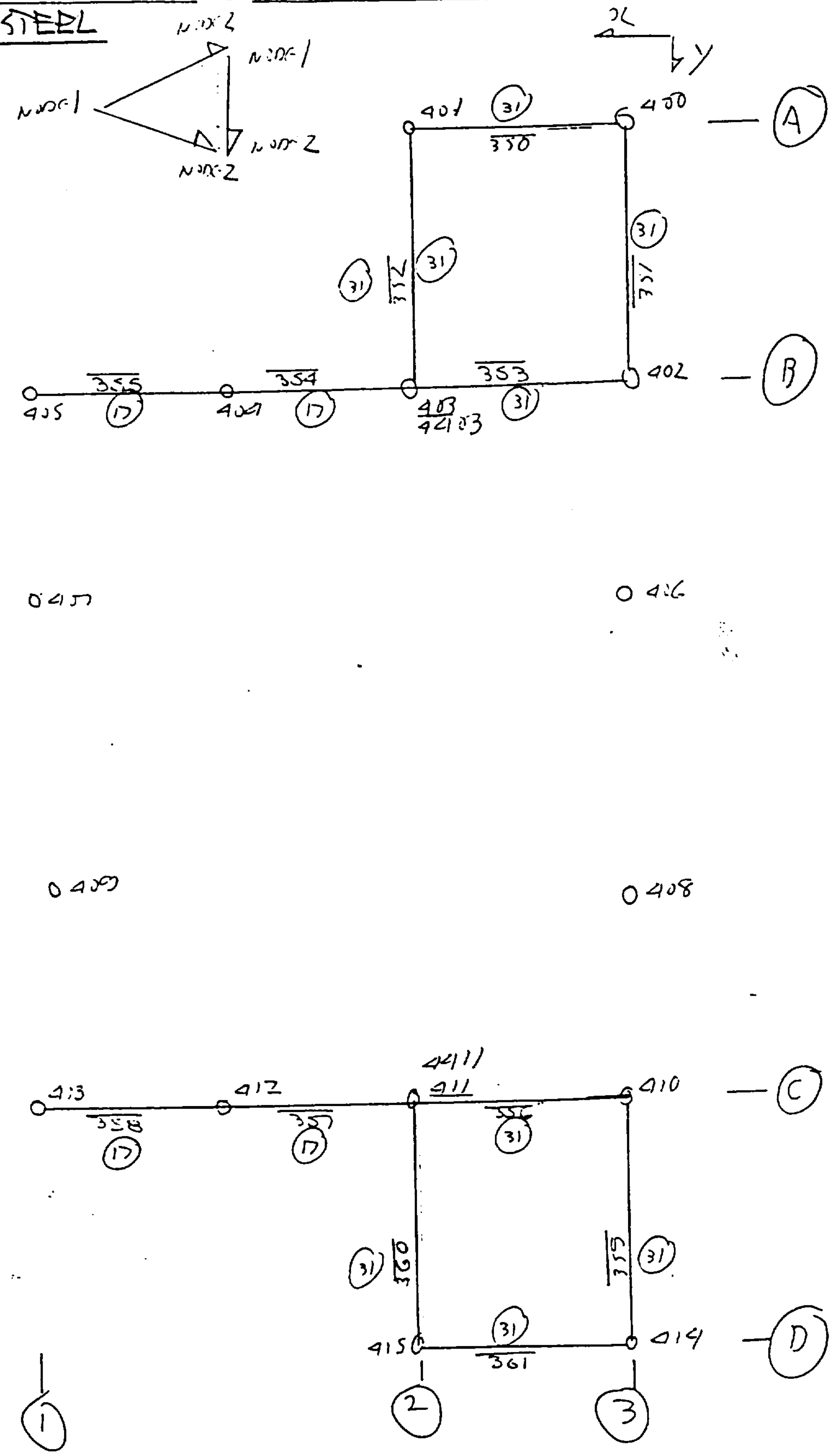
WORK PACKAGE

/ED DATE

.VED DATE REV DATE

MATH MODEL - MAIN STEEL

NODE	X	Y	Z_3	Z_4
400	0	0	1622.8	
401	168	0		
402	[illegible]	192		
403	[illegible]8	192		1623.8
404	3[illegible]8	192	1623.8	
405	46[illegible]	192	1623.8	
406	0	330		
407	468	[illegible]30		
408	0	6[illegible]6		
409	468	6[illegible]6		
410	0	74[illegible]	1627.3	
411	168	744	[illegible]627.3	1623.8
412	318	744	[illegible]	
413	468	744	[illegible]	
414	0	936	[illegible]	
415	168	936	1627[illegible]	



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NASA-MSFC-MAF

ELEV 136.

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SHEET ____ OF R-4

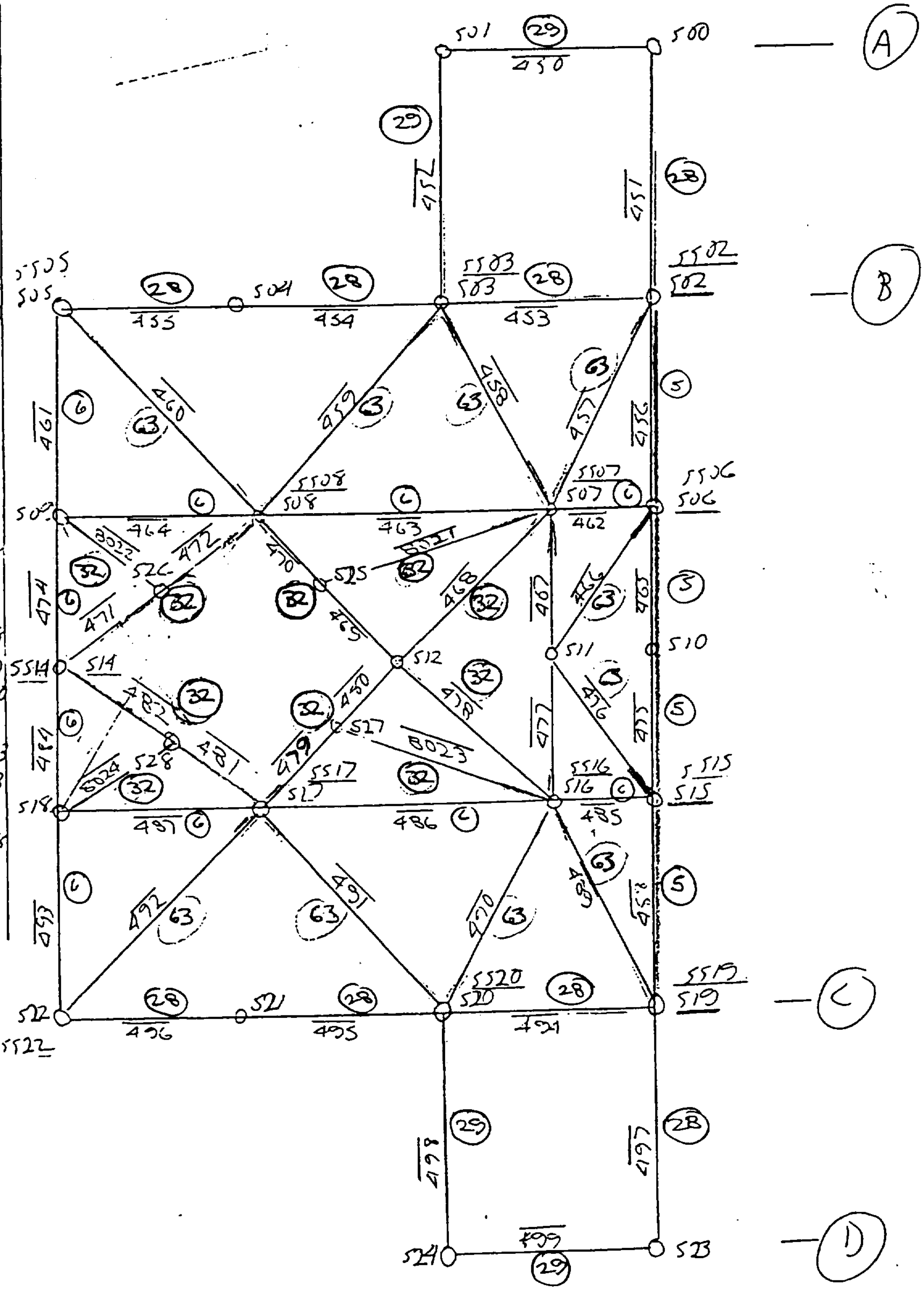
J.C. DATE 3/30 SUBJECT PFBTS.

WORK PACKAGE

ED ____ DATE ____

ED ____ DATE ____ REV ____ DATE ____

NODE	X	Y	Z3	Z4
500		0	1749.8	
501	16[illegible]	0	1749.8	
502	[illegible]	192	1742.6	1749.8
503	16[illegible]	192	1749.8	1748.8
504	31[illegible]	192	1748.8	
505	46[illegible]	192	1748.8	1742.8
506	0	354	1742.6	1742.8
507	83	354	1742.8	1748.0
508	311	354	1742.8	1748.0
509	468	[illegible]54	1742.8	
510	0	[illegible]68	1742.6	
511	83	[illegible]8	1748.8	
512	197	4[illegible]8	1748.0	
~~513~~	~~[illegible]~~	~~[illegible]~~	~~1748.0~~	
514	468	46[illegible]	1748	1742.8
515	0	582	[illegible]42.6	1742.8
516	83	582	1742.8	1748.0
517	311	582	1742.8	1748.0
518	468	582	17[illegible]8	
519	0	744	174[illegible]6	1749.3
520	168	744	1748[illegible]	1749.3
521	311	744	1748.[illegible]	
522	468	744	1748.8	1742.8
523	0	936	1749.3	
524	168	936	1749.3	
525	254	411	1748	
526	389.5	411	1748	
527	254	525	1748	
528	389.5	525	1748	



ELEV'N 146-4.

1 2 3

JC DATE 3/30 SUBJECT PFBTS

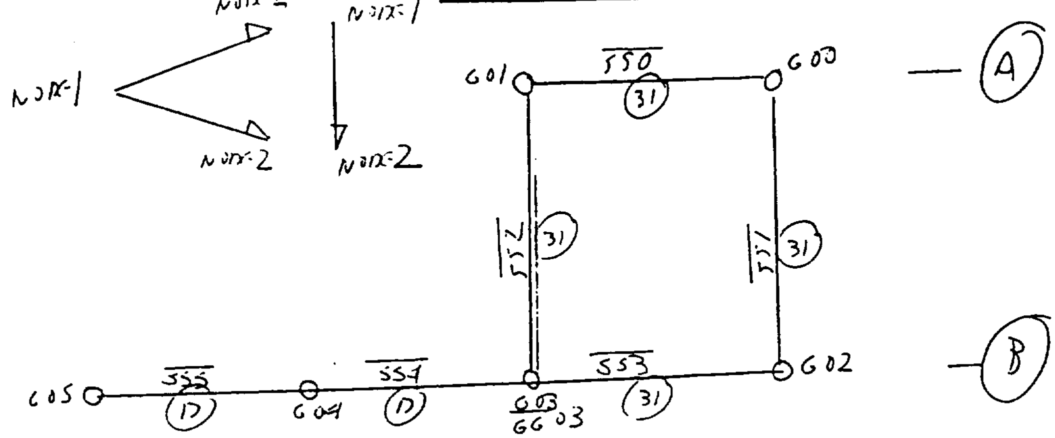
WORK PACKAGE

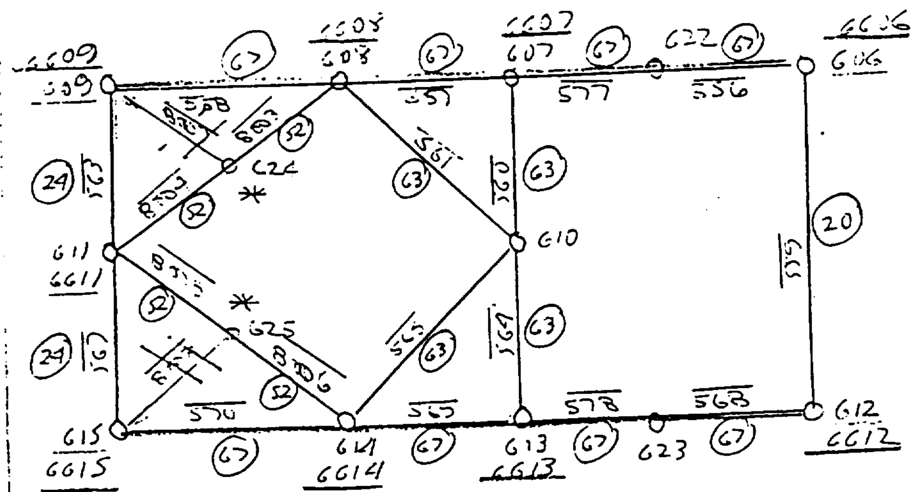
[illegible]ED ____ DATE ____

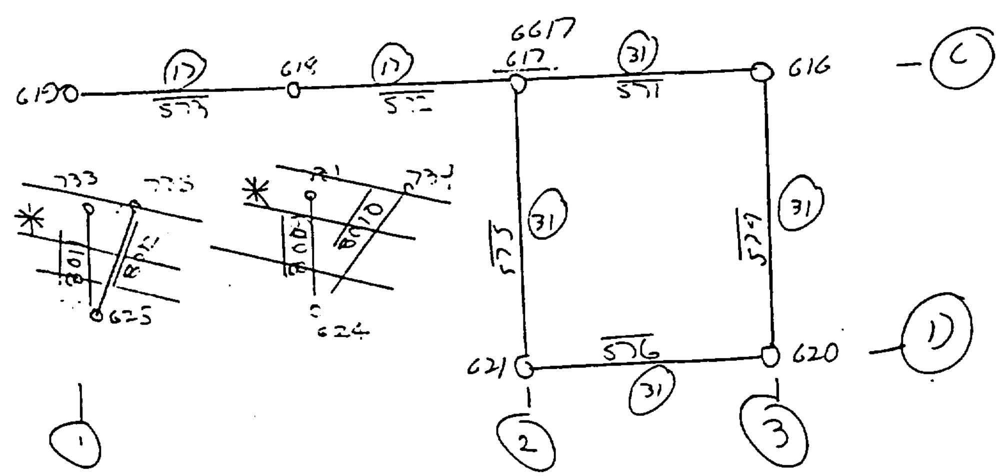
[illegible]VED ____ DATE ____ REV ____ DATE ____

MATH MODEL - MAIN STEEL

NODE	X	Y	Z1	Z2
600	0	0	1887-8	
601	[illegible]8	0	1857-8	
602	0	192	1857-8	
603	16[illegible]	192	1857-8	1863-8
604	31[illegible]	192	1853-5	
605	46[illegible]	192	1853-8	
606	0	354	1884-1	1881-1
607	157	354	1864	1881
608	~~216~~ 311	[illegible]4	1881-7	1881
609	468	[illegible]4	1881-4	1881-1
610	157	468	1884	
611	468	46[illegible]	1880-4	1884
612	0	55[illegible]	1874	1881
613	197	582	1882-4	1881
614	~~216~~ 311	582	[illegible]1-4	1881-1
615	468	582	[illegible]74	1881-1
616	0	744	1857-3	
617	168	744	15[illegible]-3	1863-8
618	311	744	15[illegible]	
619	468	744	153[illegible]	
620	0	936	1857-[illegible]	
621	168	936	1857-3	
622	[illegible]	354	[illegible]	
623	[illegible]	582	[illegible]	







ELEV 157'-8

MARTIN MARIETTA
MICHOUD OPERATIONS

SHEET ____ OF 12-6

JC DATE 3/30 SUBJECT PFBTS

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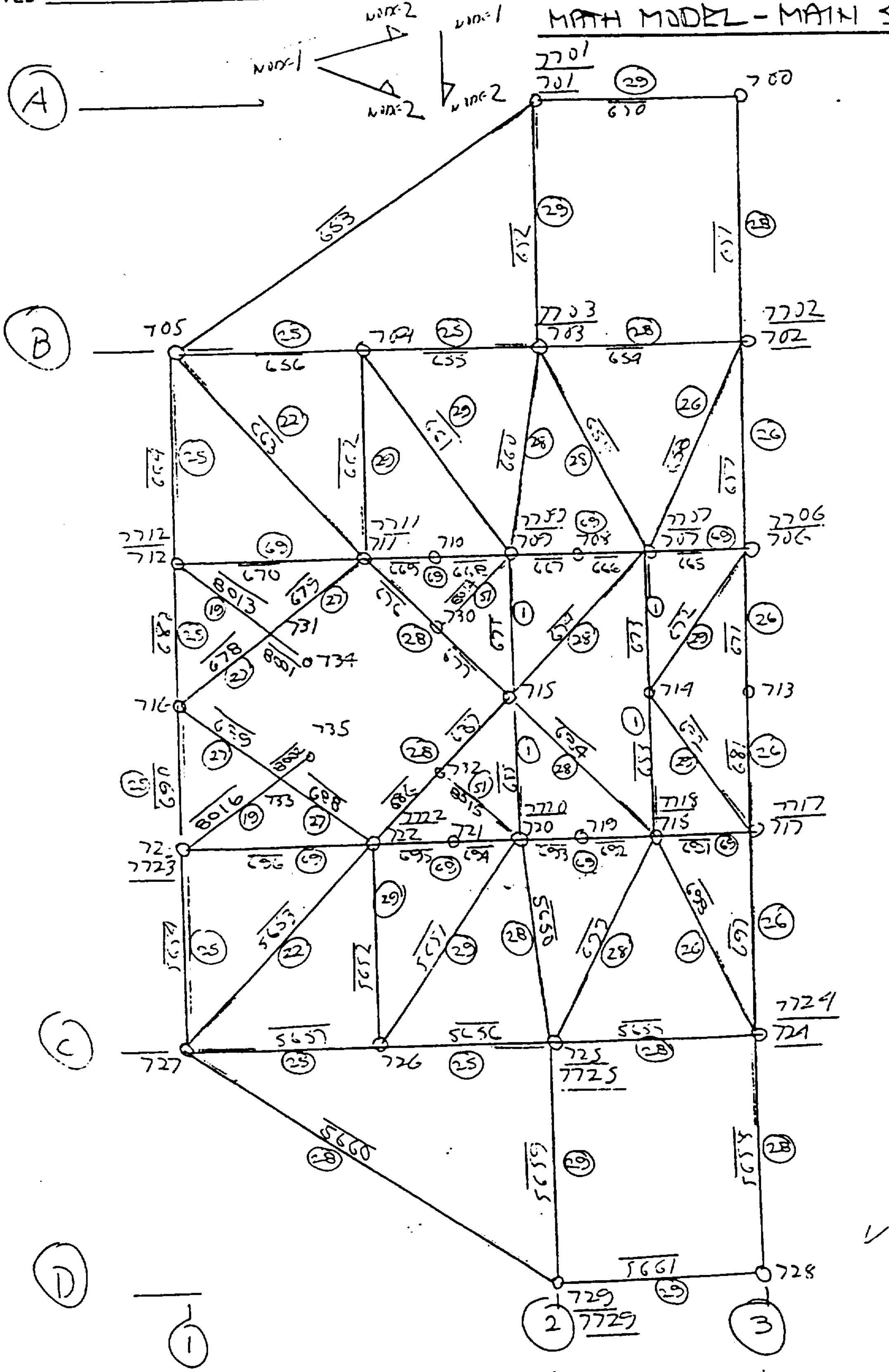
MATH MODEL - MAIN STEEL



NODE	x	Y	Z3	Z4
700	0	0	2021.8	
701	168	0	2021.8	2020.7
702	0	192	2021.8	2020.7
703	168	192	2021.8	2020.7
704	311	192	2020.7	
705	468	192	2020.7	
706	0	354	2024.1	2020.7
707	84	354	2024.1	2020.7
708	150	354	2024.1	
709	197	354	2024.1	2020.7
710	244	354	2024.1	
711	311	354	2024.1	2020.7
712	468	354	2024.1	2020.7
713	0	468	2020.7	
714	84	468	2020.7	
715	197	468	2020.7	
716	468	468	2020.7	
717	0	582	2024.1	2020.7
718	84	582	2024.1	2020
719	150	582	2024.1	
720	197	582	2024.1	2020
721	244	582	2024.1	
722	311	582	2024.1	2020
723	468	582	2024.1	2020
724	0	744	2021.3	2020
725	168	744	2021.3	2020
726	311	744	2020.7	
727	468	744	2020.7	
728	0	936	2021.3	
729	168	936	2021.3	202
~~730~~	~~258~~	~~407~~	~~2020.7~~	
~~731~~	~~320.44~~	~~397.[illegible]~~	~~2020.7~~	
~~732~~	~~258~~	~~[illegible]~~	~~2020.7~~	
~~733~~	~~320.44~~	~~528.[illegible]~~	~~2020.7~~	
730	253.33	411.67	2020.7	
731	364.36	392.75	2020.7	
732	253.36	524.36	2020.7	
733	364.36	545.25	2020.7	

ELEVN 169'-0

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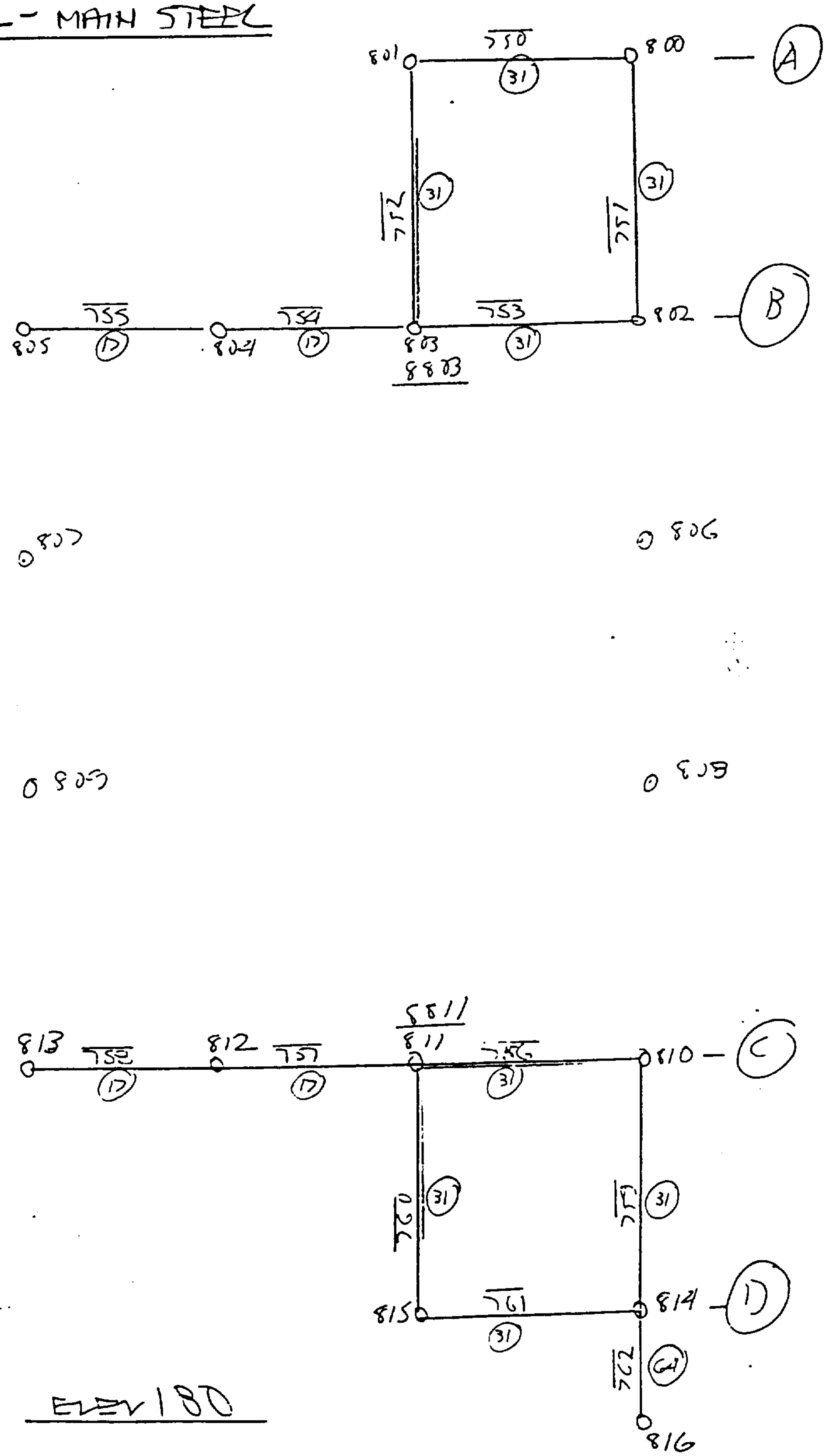
ED DATE REV DATE

MATH MODEL - MAIN STEEL

NODE	X	Y	Z-3	Z-1
800	0	0	2159.8	
801	168	0	2159.8	
802	0	192	2159.8	
803	168	192	2155.8	2159.8
804	318	192	2155.8	
805	468	192	2155.8	
806	0	330	2157.25	
807	468	330	2157.25	
808	0	606	2157.25	
809	468	606	2157.25	
810	0	744	2159.3	
811	168	744	2155.8	2159.3
812	318	744	2155.8	
813	468	744	2155.8	
814	0	936	2159.3	
815	168	936	2159.3	
816	0	1012	2162.[illegible]	



ELEV 180

MARTIN MARIETTA
MICHOUD OPERATIONS

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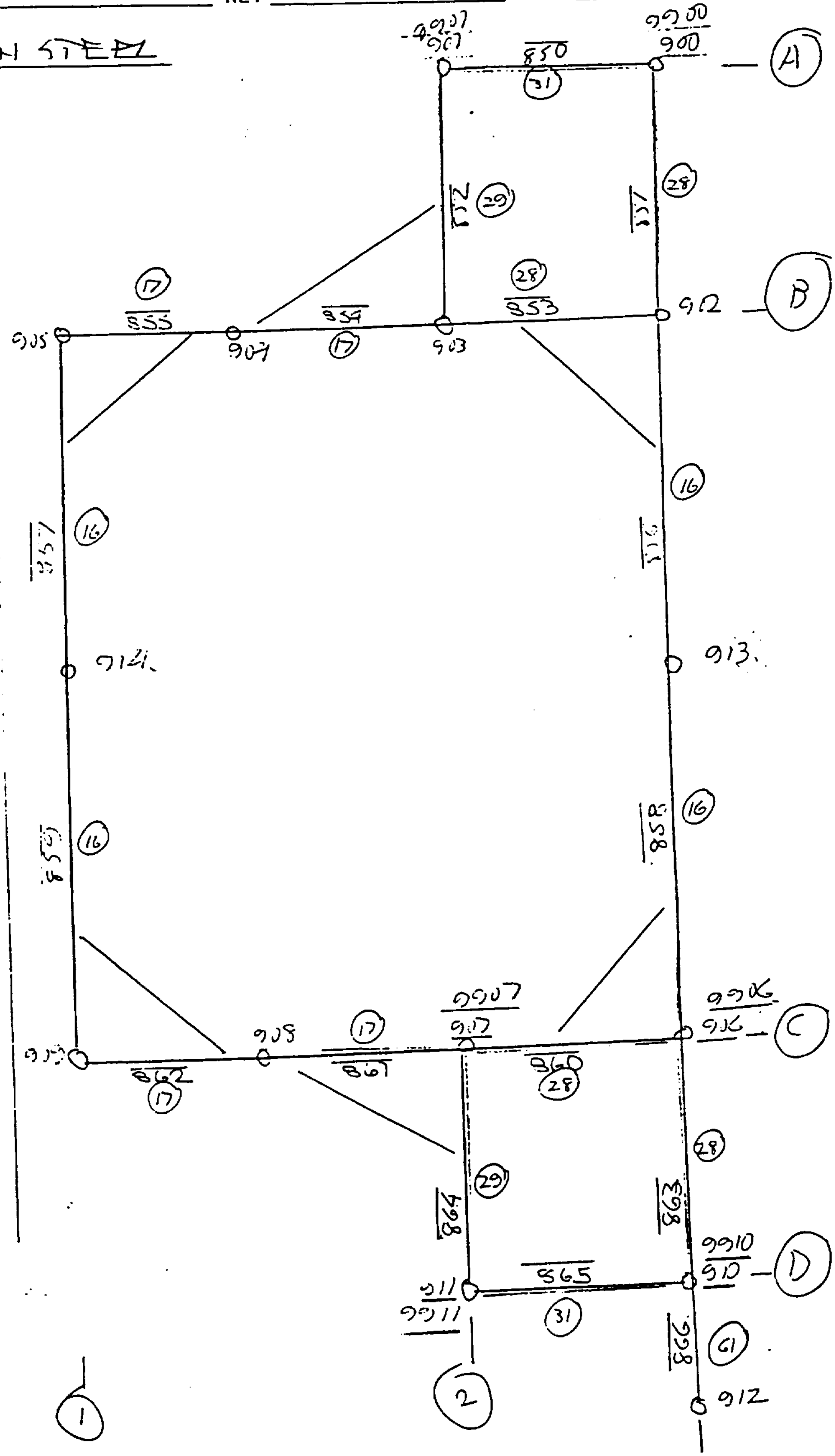
MATH MODEL - MAIN STEEL

NODE	x	Y	Z3	Z4
900	0	0	2293.8	2295.8
901	168	0	2293.8	2295.8
902	0	192	2293.8	
903	168	192	2293.8	
904	318	192	2293.8	
905	468	192	2293.8	
906	0	744	2293.3	2293.8
907	168	744	2293.3	2293.8
908	318	744	2293.8	
909	468	744	2293.8	
910	0	936	2293.3	2295.3
911	168	936	2293.3	2295.3
912	0	1088	2293.1	
913	0	468	2293.8	
914	468	468	2293.8	



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ELEV 191-8.

MARTIN MARIETTA
MICHOUD OPERATIONS

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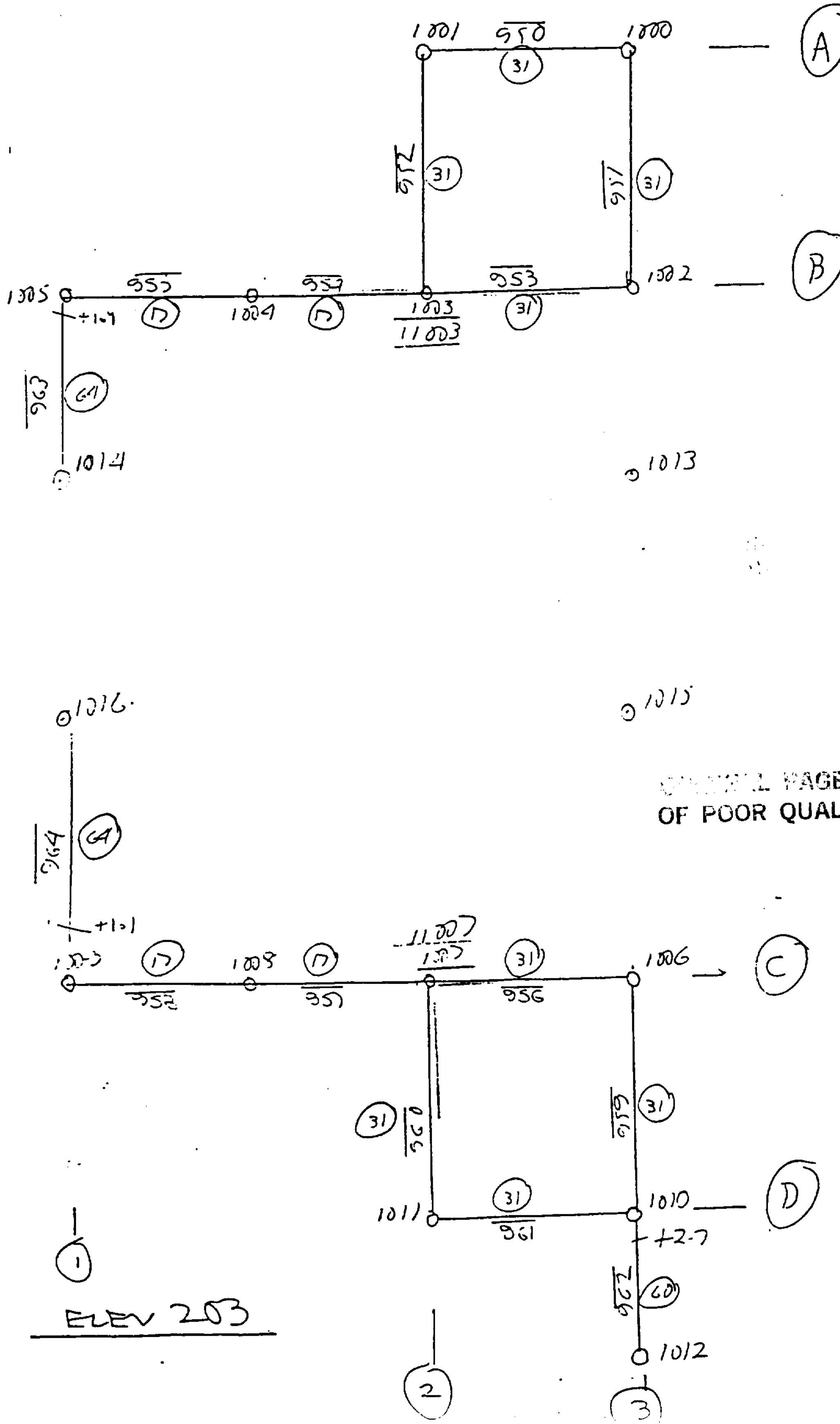
MATH MODEL - MAIN STEEL

NODE	X	Y	Z_3	Z_4
1000	0	0	2431.8	
1001	168	0	2431.8	
1002	0	192	2431.8	
1003	168	192	2431.8	2427.8
1004	312	192	2427.8	
1005	468	192	2427.8	
1006	0	744	2431.3	
1007	168	744	2431.3	2427.8
1008	312	744	2427.8	
1009	468	744	2427.8	
1010	0	936	2431.3	
1011	168	936	2431.3	
1012	0	1164	[illegible]	
1013	0	330	[illegible]	
1014	468	330	[illegible]	
1015	0	606	2425.9	
1016	468	606	2427.9	



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ARTIN MARIETTA
MICHOUD OPERATIONS

JC DATE 3/30 SUBJECT PFBTS

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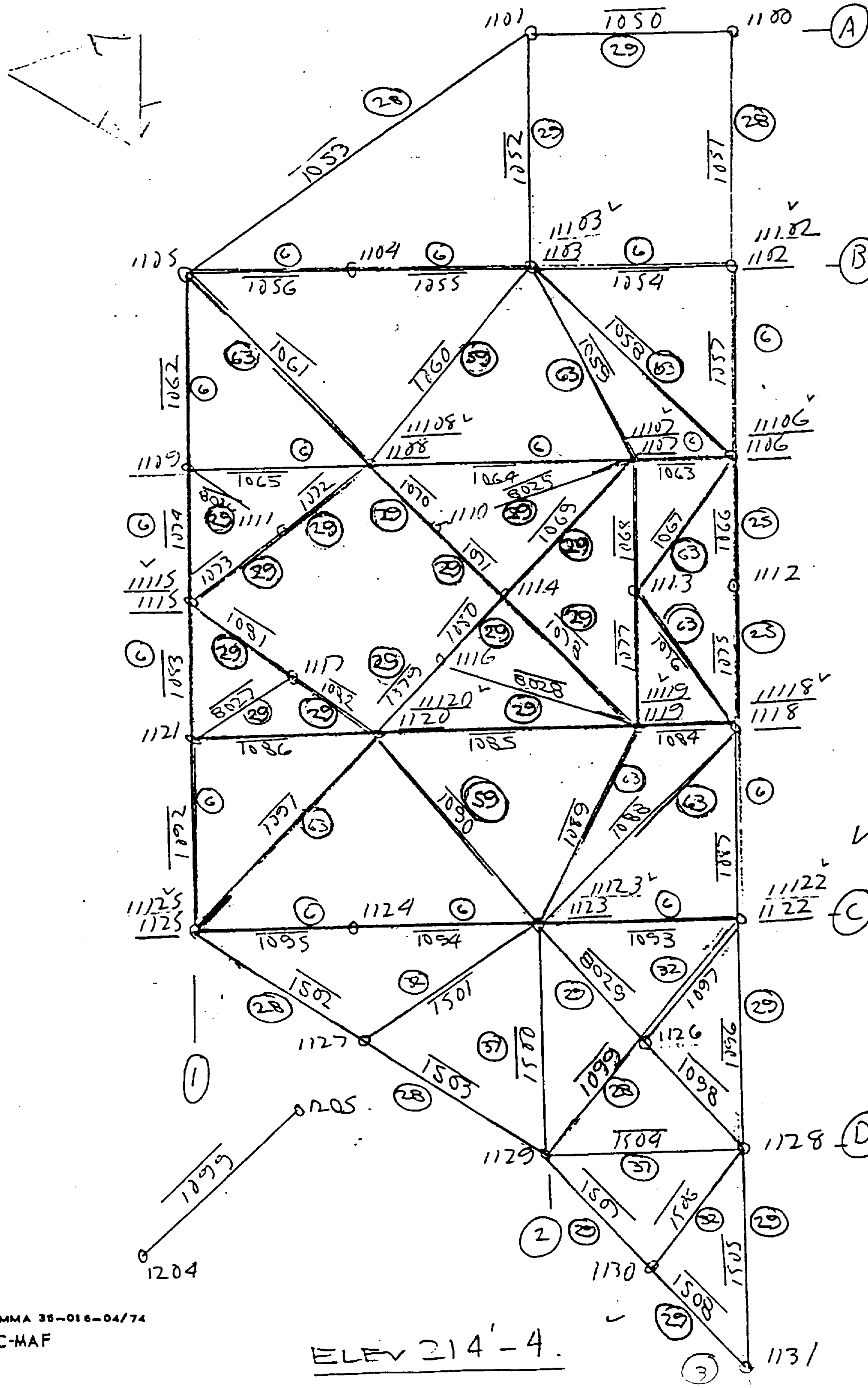

ELEV 214'-4.

NODE	x	Y	z_3	z_4
1100	0	0	2565-7	
1101	168	0	2565-7	
1102	0	192	2558-8	2565
1103	168	192	2558-8	2565
1104	319	192	2558-8	
1105	468	192	2558-8	
1106	[illegible]	343-5	2558-8	256
1107	7[illegible]	343-5	2558-8	256
1108	319	343-5	2558-8	256
1109	46[illegible]	343-5	2558-8	
1110	255[illegible]	419-[illegible]	2564	
1111	381-[illegible]	396-[illegible]	2564	
1112	0	[illegible]68	2564	
1113	75	[illegible]68	2564	
1114	197	[illegible]68	2564	
1115	468	[illegible]68	2564-4	2558
1116	255-5	5[illegible]4	2564	
1117	381-7	5[illegible]	2564	
1118	0	59[illegible]	2558-8	256
1119	75	597	2558-8	256
1120	319	597	2558-8	256
1121	468	592-5	[illegible]558-8	
1122	0	744	[illegible]	2564
1123	168	744	[illegible]	2564
1124	319	744	2[illegible]	
1125	468	744	2[illegible]	2564
1126	84	890	256[illegible]8	
1127	319	890	256[illegible]8	
1128	0	936	2564[illegible]	
1129	168	936	2564[illegible]	
1130	84	1050	2564[illegible]	
1131	0	1164	2564-8	

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JC DATE 3/30 SUBJECT PFBTS

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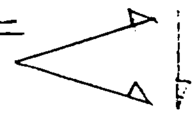
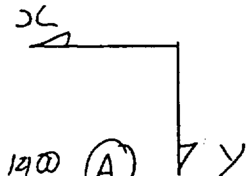
MATH MODEL - MATH STEEL





NODE	X	Y	Z3	Z4
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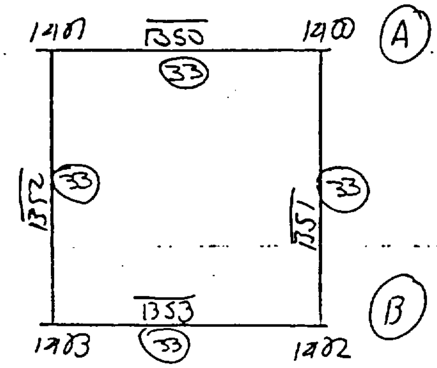
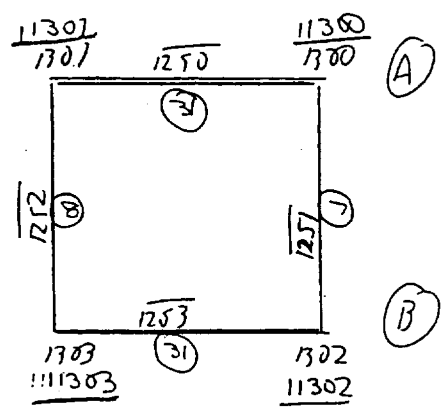
1201	168	0		
1202	0	192		
1203	168	192		
1300	0	0	2773.75	2773.75
1301	168	0		
1302	0	192		
1303	168	192		
1400	0	0	2882	
1401	168	0		
1402	0	192		
1403	168	192		
1204	168	936	2586	
1205	0	744	2586	

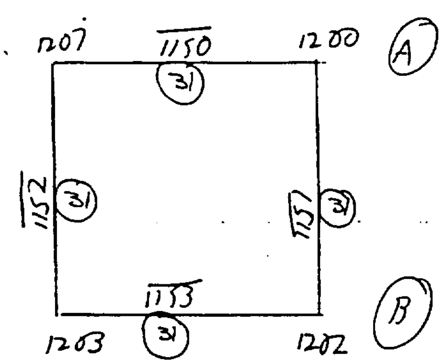
ELGV 241'-10



ELGV 231'-10



ELGV 223'-1



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MARTIN MARIETTA
MICHOUD OPERATIONS

SHEET ____ OF 12-12

EJP DATE 8/30 SUBJECT PFBTS

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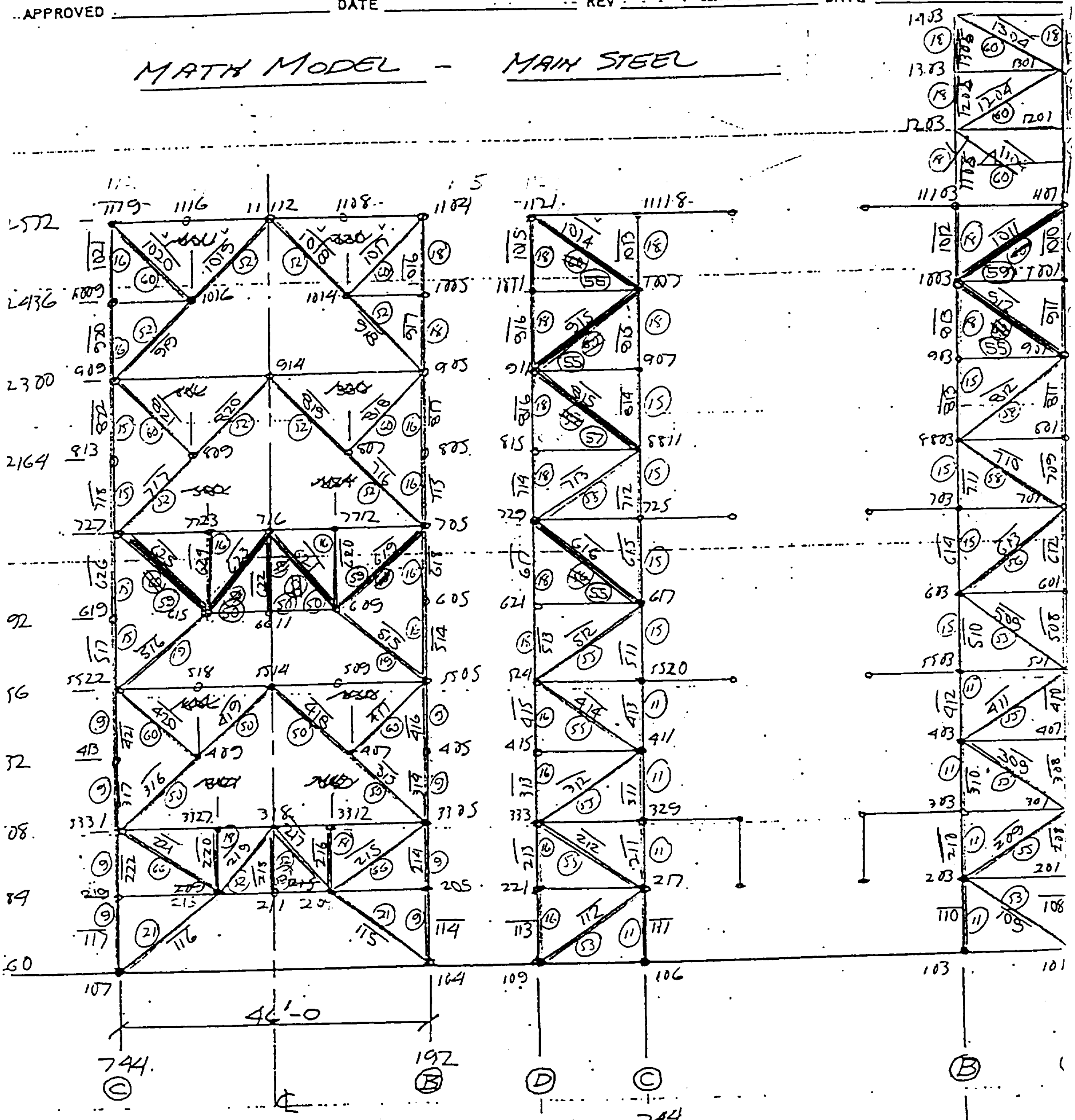
MATH MODEL - MAIN STEEL



EAST ELEV @ ①

XS 468

EAST ELEV @ ②

XS 168

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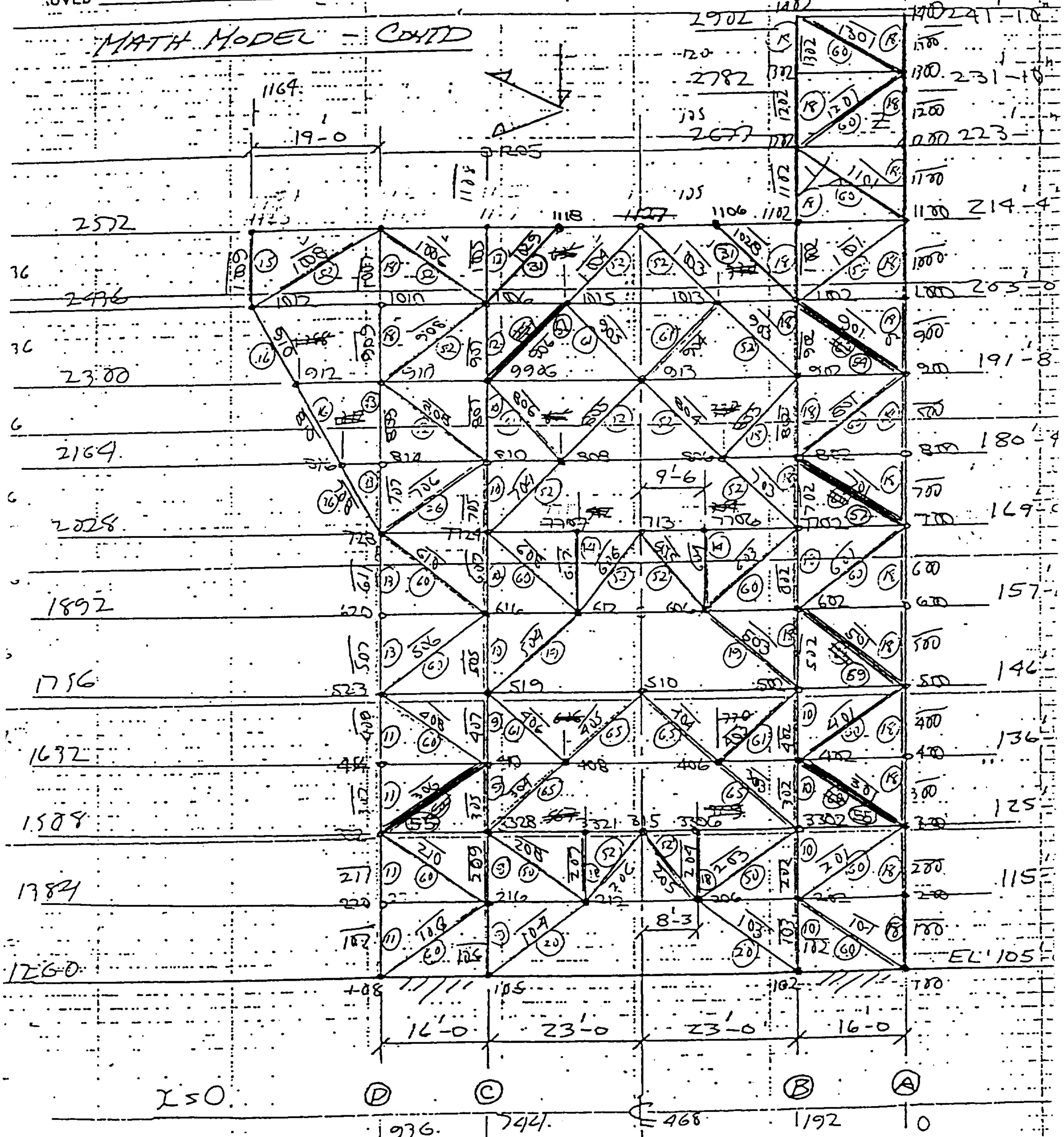
MATH MODEL - CONT'D



EAST ELEV. @ 3

MARTIN MARIETTA
MICHOUD OPERATIONS

SHEET ___ OF 12-14

BY JC DATE 3/30 SUBJECT PFBTS

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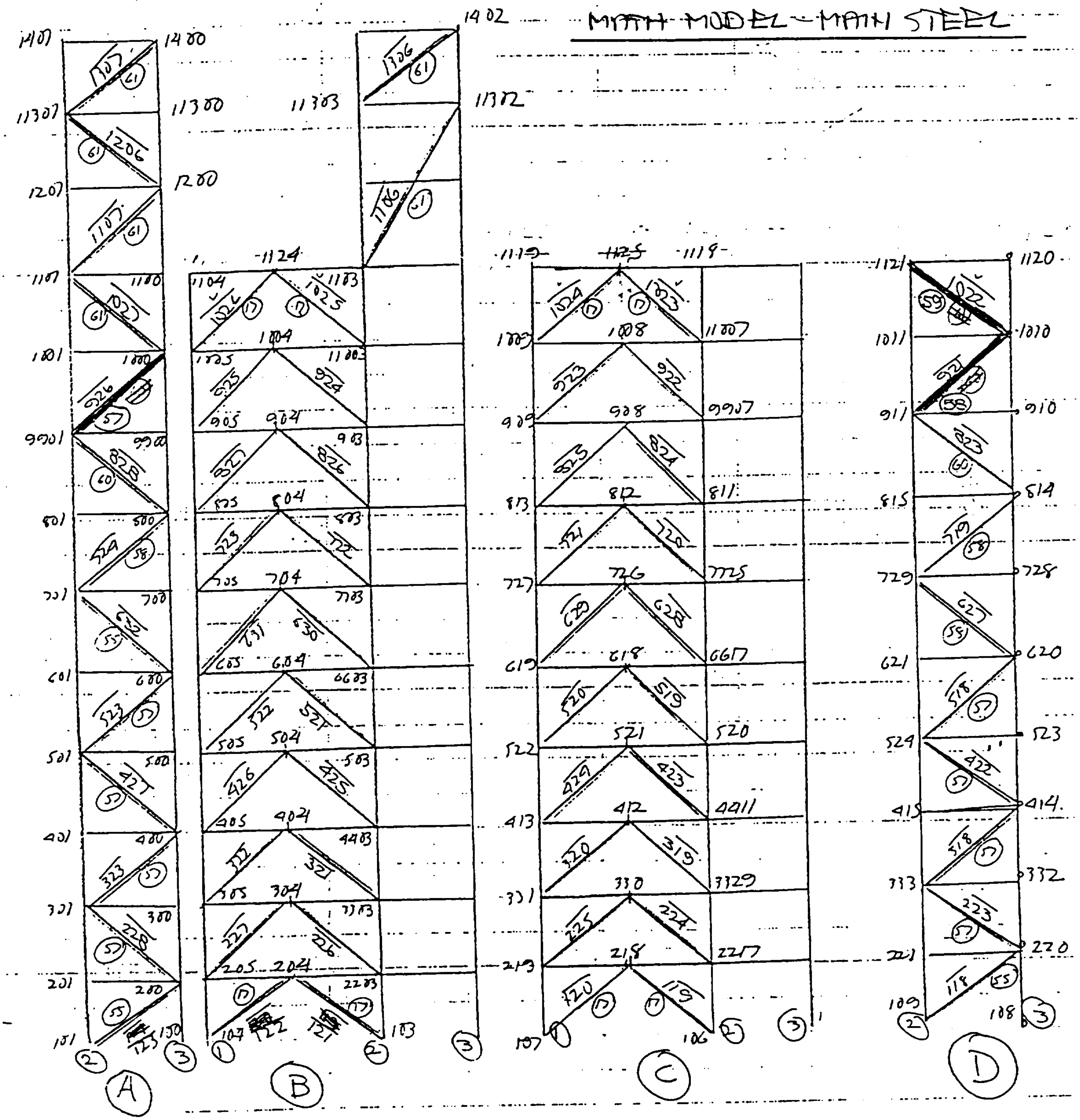
MATH MODEL - MAIN STEEL



SOUTH ELEVATION

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MARTIN MARIETTA
MICHOUD OPERATIONS

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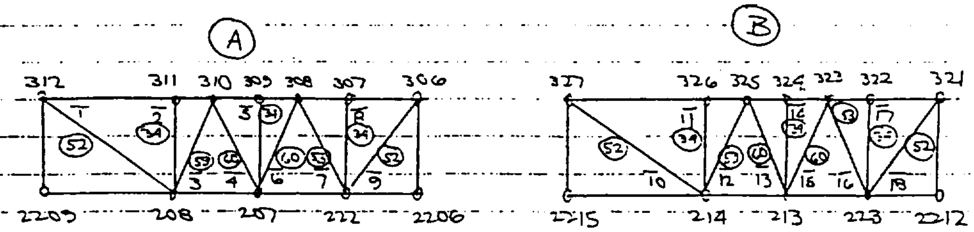
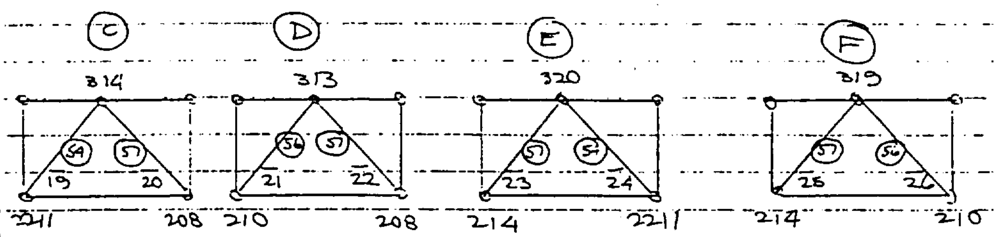
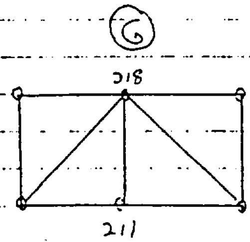
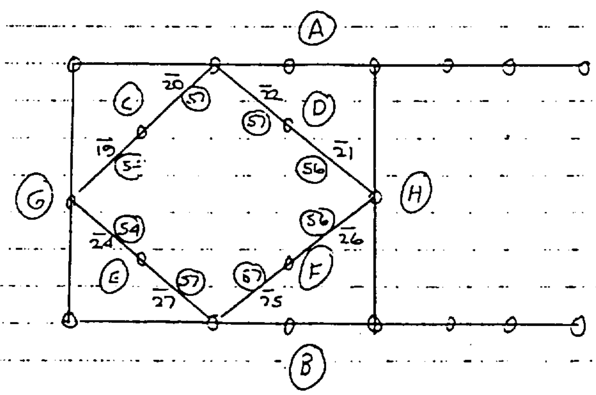
MATH MODEL – MAIN STEEL

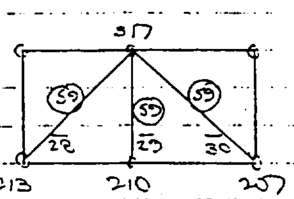
TRUSSES LEVEL 115-125



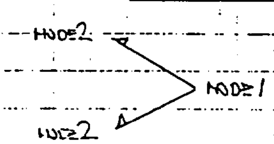








TANK SUPPORT STRUCTURE



ELEMENTS NOT DEFINED HERE ARE GIVEN ON VERTICALS OR ELEVATIONS.

ARTIN MARIETTA
MICHOUD OPERATIONS

SHEET ____ OF 12-16

JC DATE 3/30 SUBJECT PFBTS

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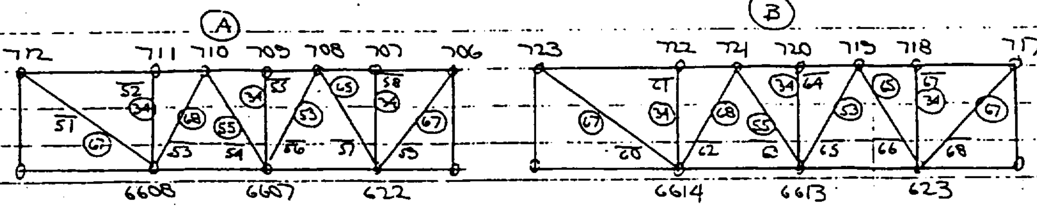
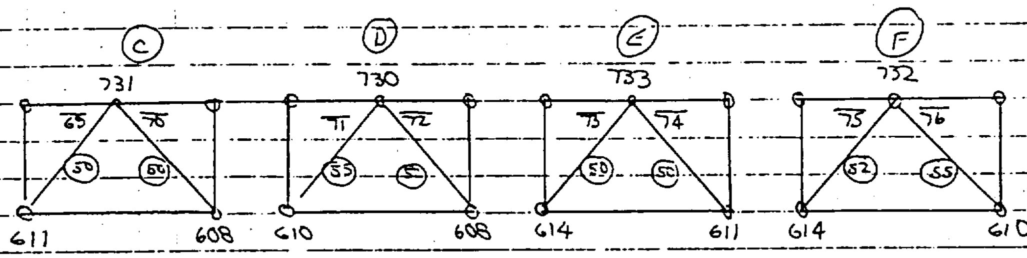
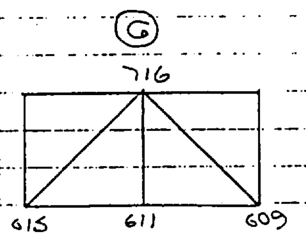
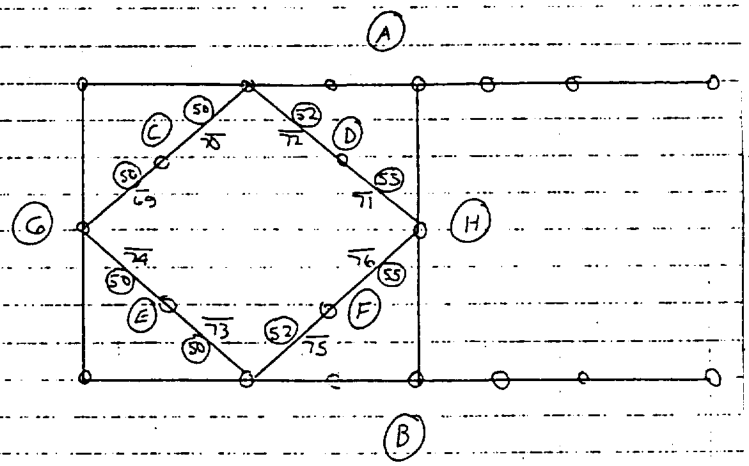
MATH MODEL – MAIN STEEL

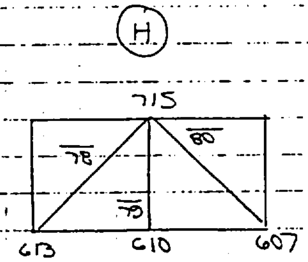
TRUSSES LEVEL 157-169



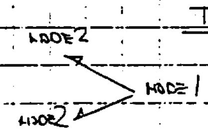








TANK SUPPORT STRUCTURE



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MARTIN MARIETTA
MICHOUD OPERATIONS

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MATH MODEL - MAIN STEEL

MODES

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GRID         735      10 365.750 524.0702020.700        20
GRID         624      10 364.360 392.7501888.400        20
GRID         625      10 364.360 543.2501888.400        20

$
$*****************************BEGIN GRIDS*********************************
$
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GRID         101      10 168.000   0.0001260.000        20
GRID         102      10   0.000 192.0001260.000        20
GRID         103      10 168.000 192.0001260.000        20
GRID         104      10 468.000 192.0001260.000        20
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GRID         107      10 468.000 744.0001260.000        20
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GRID         168      102159.300   0.000   0.000        20
GRID         200      10   0.000   0.0001379.800        20
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GRID         217      10 168.000 744.0001379.300        20
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MATH MODEL - MAIN STEEL

NODES

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GRID	309	10	197.000	369.0001504.300	20
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GRID	311	10	297.000	369.0001504.300	20
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GRID	323	10	156.000	567.0001504.300	20
GRID	324	10	197.000	567.0001504.300	20
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GRID	328	10	0.000	744.0001501.300	20
GRID	329	10	168.000	744.0001501.300	20
GRID	330	10	297.000	744.0001500.800	20
GRID	331	10	468.000	744.0001500.800	20
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GRID	401	10	168.000	0.0001627.800	20
GRID	402	10	0.000	192.0001627.800	20
GRID	403	10	168.000	192.0001627.800	20
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GRID	408	10	0.000	606.0001623.800	20
GRID	409	10	468.000	606.0001623.800	20
GRID	410	10	0.000	744.0001627.300	20
GRID	411	10	168.000	744.0001627.300	20
GRID	412	10	318.000	744.0001623.800	20
GRID	413	10	468.000	744.0001623.800	20
GRID	414	10	0.000	936.0001627.300	20
GRID	415	10	168.000	936.0001627.300	20
GRID	500	10	0.000	0.0001749.800	20
GRID	501	10	168.000	0.0001749.800	20
GRID	502	10	0.000	192.0001742.600	20
GRID	503	10	168.000	192.0001745.800	20
GRID	504	10	311.000	192.0001748.800	20
GRID	505	10	468.000	192.0001748.800	20
GRID	506	10	0.000	354.0001742.600	20
GRID	507	10	83.000	354.0001742.800	20
GRID	508	10	311.000	354.0001742.800	20
GRID	509	10	468.000	354.0001742.800	20
GRID	510	10	0.000	468.0001742.600	20
GRID	511	10	83.000	468.0001748.800	20
GRID	512	10	197.000	468.0001748.000	20
GRID	514	10	468.000	468.0001748.000	20
GRID	515	10	0.000	582.0001742.600	20
GRID	516	10	83.000	582.0001742.800	20
GRID	517	10	311.000	582.0001742.800	20

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MATH MODEL – MAIN STEEL

NODES

```
GRID     518   10 468.000 582.0001742.800      20
GRID     519   10   0.000 744.0001742.600      20
GRID     520   10 168.000 744.0001748.800      20
GRID     521   10 311.000 744.0001748.800      20
GRID     522   10 468.000 744.0001748.800      20
GRID     523   10   0.000 936.0001749.300      20
GRID     524   10 168.000 936.0001749.300      20
GRID     525   10 254.000 411.0001748.000      20
GRID     526   10 374.440 400.0001748.000      20
GRID     527   10 254.000 525.0001748.000      20
GRID     528   10 374.440 535.9401748.000      20
GRID     600   10   0.000   0.0001887.800      20
GRID     601   10 168.000   0.0001887.800      20
GRID     602   10   0.000 192.0001887.800      20
GRID     603   10 168.000 192.0001887.800      20
GRID     604   10 311.000 192.0001883.800      20
GRID     605   10 468.000 192.0001883.800      20
GRID     606   10   0.000 354.0001884.400      20
GRID     607   10 197.000 354.0001888.400      20
GRID     608   10 311.000 354.0001888.400      20
GRID     609   10 468.000 354.0001888.400      20
GRID     610   10 197.000 468.0001888.400      20
GRID     611   10 468.000 468.0001888.400      20
GRID     612   10   0.000 582.0001884.400      20
GRID     613   10 197.000 582.0001888.400      20
GRID     614   10 311.000 582.0001888.400      20
GRID     615   10 468.000 582.0001884.400      20
GRID     616   10   0.000 744.0001887.300      20
GRID     617   10 168.000 744.0001887.300      20
GRID     618   10 311.000 744.0001883.800      20
GRID     619   10 468.000 744.0001883.800      20
GRID     620   10   0.000 936.0001887.300      20
GRID     621   10 168.000 936.0001887.300      20
GRID     622   10  83.000 354.0001888.100      20
GRID     623   10  83.000 582.0001889.100      20
GRID     700   10   0.000   0.0002021.800      20
GRID     701   10 168.000   0.0002021.800      20
GRID     702   10   0.000 192.0002021.800      20
GRID     703   10 168.000 192.0002021.800      20
GRID     704   10 311.000 192.0002020.700      20
GRID     705   10 468.000 192.0002020.700      20
GRID     706   10   0.000 354.0002024.100      20
GRID     707   10  84.000 354.0002024.100      20
GRID     708   10 150.000 354.0002024.100      20
GRID     709   10 197.000 354.0002024.100      20
GRID     710   10 244.000 354.0002024.100      20
GRID     711   10 311.000 354.0002024.100      20
GRID     712   10 468.000 354.0002024.100      20
GRID     713   10   0.000 468.0002020.700      20
GRID     714   10  84.000 468.0002020.700      20
GRID     715   10 197.000 468.0002020.700      20
GRID     716   10 468.000 468.0002020.700      20
GRID     717   10   0.000 582.0002024.100      20
GRID     718   10  84.000 582.0002024.100      20
GRID     719   10 150.000 582.0002024.100      20
GRID     720   10 197.000 582.0002024.100      20
GRID     721   10 244.000 582.0002024.100      20
GRID     722   10 311.000 582.0002024.100      20
GRID     723   10 468.000 582.0002024.100      20
GRID     724   10   0.000 744.0002021.300      20
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MATH MODEL - MAIN STEEL

NODES -

GRID	725	10	168.000	744.000	2021.300	20
GRID	726	10	311.000	744.000	2020.700	20
GRID	727	10	468.000	744.000	2020.700	20
GRID	728	10	0.000	536.000	2021.300	20
GRID	729	10	168.000	536.000	2021.300	20
GRID	730	10	253.360	411.640	2020.700	20
GRID	731	10	379.830	403.980	2020.700	20
GRID	732	10	253.360	524.360	2020.700	20
GRID	733	10	375.830	532.020	2020.700	20
GRID	800	10	0.000	0.000	2159.800	20
GRID	801	10	168.000	0.000	2159.800	20
GRID	802	10	0.000	192.000	2159.800	20
GRID	803	10	168.000	192.000	2155.800	20
GRID	804	10	318.000	192.000	2155.800	20
GRID	805	10	468.000	192.000	2155.800	20
GRID	806	10	0.000	330.000	2157.250	20
GRID	807	10	468.000	330.000	2157.250	20
GRID	808	10	0.000	606.000	2157.250	20
GRID	809	10	468.000	606.000	2157.250	20
GRID	810	10	0.000	744.000	2159.300	20
GRID	811	10	168.000	744.000	2155.800	20
GRID	812	10	318.000	744.000	2155.800	20
GRID	813	10	468.000	744.000	2155.800	20
GRID	814	10	0.000	536.000	2159.300	20
GRID	815	10	168.000	536.000	2159.300	20
GRID	816	10	0.000	1012.000	2162.500	20
GRID	900	10	0.000	0.000	2293.800	20
GRID	901	10	168.000	0.000	2293.800	20
GRID	902	10	0.000	192.000	2293.800	20
GRID	903	10	168.000	192.000	2293.800	20
GRID	904	10	318.000	192.000	2293.800	20
GRID	905	10	468.000	192.000	2293.800	20
GRID	906	10	0.000	744.000	2293.300	20
GRID	907	10	168.000	744.000	2293.300	20
GRID	908	10	318.000	744.000	2293.800	20
GRID	909	10	468.000	744.000	2293.800	20
GRID	910	10	0.000	536.000	2293.300	20
GRID	911	10	168.000	536.000	2293.300	20
GRID	912	10	0.000	1088.000	2298.100	20
GRID	913	10	0.000	468.000	2293.800	20
GRID	914	10	468.000	468.000	2293.800	20
GRID	1000	10	0.000	0.000	2431.800	20
GRID	1001	10	168.000	0.000	2431.800	20
GRID	1002	10	0.000	192.000	2431.800	20
GRID	1003	10	168.000	192.000	2431.800	20
GRID	1004	10	319.000	192.000	2427.800	20
GRID	1005	10	468.000	192.000	2427.800	20
GRID	1006	10	0.000	744.000	2431.300	20
GRID	1007	10	168.000	744.000	2431.300	20
GRID	1008	10	319.000	744.000	2427.800	20
GRID	1009	10	468.000	744.000	2427.800	20
GRID	1010	10	0.000	536.000	2431.300	20
GRID	1011	10	168.000	536.000	2431.300	20
GRID	1012	10	0.000	1164.000	2434.000	20
GRID	1013	10	0.000	330.000	2428.900	20
GRID	1014	10	468.000	330.000	2428.900	20
GRID	1015	10	0.000	606.000	2428.900	20
GRID	1016	10	468.000	606.000	2428.900	20
GRID	1100	10	0.000	0.000	2565.700	20
GRID	1101	10	168.000	0.000	2565.700	20

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Math Model - Main Steel

Nodes

GRID	1102	10	0.000	192.000	2558.800	20
GRID	1103	10	168.000	192.000	2558.800	20
GRID	1104	10	319.000	192.000	2558.800	20
GRID	1105	10	468.000	192.000	2558.800	20
GRID	1106	10	0.000	343.500	2558.800	20
GRID	1107	10	75.000	343.500	2558.800	20
GRID	1108	10	319.000	343.500	2558.800	20
GRID	1109	10	468.000	343.500	2558.800	20
GRID	1110	10	258.000	405.750	2564.000	20
GRID	1111	10	381.150	395.460	2564.000	20
GRID	1112	10	0.000	468.000	2564.000	20
GRID	1113	10	75.000	468.000	2564.000	20
GRID	1114	10	197.000	468.000	2564.000	20
GRID	1115	10	468.000	468.000	2564.000	20
GRID	1116	10	258.000	530.250	2564.000	20
GRID	1117	10	381.150	540.540	2564.000	20
GRID	1118	10	0.000	592.500	2558.800	20
GRID	1119	10	75.000	592.500	2558.800	20
GRID	1120	10	319.000	592.500	2558.800	20
GRID	1121	10	468.000	592.500	2558.800	20
GRID	1122	10	0.000	744.000	2558.800	20
GRID	1123	10	168.000	744.000	2558.800	20
GRID	1124	10	319.000	744.000	2558.800	20
GRID	1125	10	468.000	744.000	2558.800	20
GRID	1126	10	84.000	840.000	2564.800	20
GRID	1127	10	319.000	840.000	2564.800	20
GRID	1128	10	0.000	936.000	2564.800	20
GRID	1129	10	168.000	936.000	2564.800	20
GRID	1130	10	84.000	1050.000	2564.800	20
GRID	1131	10	0.000	1164.000	2564.800	20
GRID	1200	10	0.000	0.000	2672.750	20
GRID	1201	10	168.000	0.000	2672.750	20
GRID	1202	10	0.000	192.000	2672.750	20
GRID	1203	10	168.000	192.000	2672.750	20
GRID	1204	10	168.000	936.000	2586.000	20
GRID	1205	10	0.000	744.000	2586.000	20
GRID	1300	10	0.000	0.000	2773.750	20
GRID	1301	10	168.000	0.000	2773.750	20
GRID	1302	10	0.000	192.000	2773.750	20
GRID	1303	10	168.000	192.000	2773.750	20
GRID	1400	10	0.000	0.000	2882.000	20
GRID	1401	10	168.000	0.000	2882.000	20
GRID	1402	10	0.000	192.000	2882.000	20
GRID	1403	10	168.000	192.000	2882.000	20
GRID	2203	10	168.000	192.000	1375.850	20
GRID	2206	10	0.000	369.000	1380.250	20
GRID	2209	10	468.000	369.000	1380.250	20
GRID	2211	10	468.000	468.000	1380.250	20
GRID	2212	10	0.000	567.000	1380.250	20
GRID	2215	10	468.000	567.000	1380.250	20
GRID	2217	10	168.000	744.000	1380.250	20
GRID	3301	10	168.000	0.000	1500.800	20
GRID	3302	10	0.000	192.000	1500.600	20
GRID	3303	10	168.000	192.000	1500.800	20
GRID	3305	10	468.000	192.000	1500.600	20
GRID	3306	10	0.000	369.000	1500.600	20
GRID	3307	10	98.000	369.000	1500.800	20
GRID	3309	10	197.000	369.000	1500.800	20
GRID	3311	10	297.000	369.000	1500.800	20
GRID	3312	10	468.000	369.000	1500.600	20

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Math Model - Main Steel

Nodes -

GRID	3317	10	197.000	468.000	1500.800	20
GRID	3321	10	0.000	567.000	1500.800	20
GRID	3322	10	99.000	567.000	1500.800	20
GRID	3324	10	198.000	567.000	1500.800	20
GRID	3326	10	297.000	567.000	1500.800	20
GRID	3327	10	468.000	567.000	1500.800	20
GRID	3328	10	0.000	744.000	1500.800	20
GRID	3329	10	168.000	744.000	1500.800	20
GRID	3331	10	468.000	744.000	1500.800	20
GRID	3333	10	168.000	936.000	1500.800	20
GRID	4403	10	168.000	192.000	1623.800	20
GRID	4411	10	168.000	744.000	1623.800	20
GRID	5502	10	0.000	192.000	1749.800	20
GRID	5503	10	168.000	192.000	1748.800	20
GRID	5505	10	468.000	192.000	1742.800	20
GRID	5506	10	0.000	354.000	1742.800	20
GRID	5507	10	83.000	354.000	1748.000	20
GRID	5508	10	311.000	354.000	1748.000	20
GRID	5514	10	468.000	468.000	1742.800	20
GRID	5515	10	0.000	582.000	1742.800	20
GRID	5516	10	83.000	582.000	1748.000	20
GRID	5517	10	311.000	582.000	1748.000	20
GRID	5519	10	0.000	744.000	1749.300	20
GRID	5520	10	168.000	744.000	1749.300	20
GRID	5522	10	468.000	744.000	1742.800	20
GRID	6603	10	168.000	192.000	1863.800	20
GRID	6606	10	0.000	354.000	1888.100	20
GRID	6607	10	197.000	354.000	1888.100	20
GRID	6608	10	311.000	354.000	1888.100	20
GRID	6609	10	468.000	354.000	1888.100	20
GRID	6611	10	468.000	468.000	1884.400	20
GRID	6612	10	0.000	582.000	1888.100	20
GRID	6613	10	197.000	582.000	1888.100	20
GRID	6614	10	311.000	582.000	1888.100	20
GRID	6615	10	468.000	582.000	1888.100	20
GRID	6617	10	168.000	744.000	1863.800	20
GRID	7701	10	168.000	0.000	2020.700	20
GRID	7702	10	0.000	192.000	2020.700	20
GRID	7703	10	168.000	192.000	2020.700	20
GRID	7706	10	0.000	354.000	2020.700	20
GRID	7707	10	84.000	354.000	2020.700	20
GRID	7709	10	197.000	354.000	2020.700	20
GRID	7711	10	311.000	354.000	2020.700	20
GRID	7712	10	468.000	354.000	2020.700	20
GRID	7717	10	0.000	582.000	2020.700	20
GRID	7718	10	84.000	582.000	2020.700	20
GRID	7720	10	197.000	582.000	2020.700	20
GRID	7722	10	311.000	582.000	2020.700	20
GRID	7723	10	468.000	582.000	2020.700	20
GRID	7724	10	0.000	744.000	2020.700	20
GRID	7725	10	168.000	744.000	2020.700	20
GRID	7729	10	168.000	936.000	2020.700	20
GRID	8803	10	168.000	192.000	2159.800	20
GRID	8811	10	168.000	744.000	2159.800	20
GRID	9900	10	0.000	0.000	2295.800	20
GRID	9901	10	168.000	0.000	2295.800	20
GRID	9906	10	0.000	744.000	2295.800	20
GRID	9907	10	168.000	744.000	2295.800	20
GRID	9910	10	0.000	936.000	2295.300	20
GRID	9911	10	168.000	936.000	2295.300	20

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MATH MODEL - MAIN STEEL

NODES

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GRID      11003     10 168.CC0 192.C002427.E00      20
GRID      11007     10 168.CC0 744.C002427.800      20
GRID      11102     10   0.G00 192.CC02565.700      20
GRID      11103     10 168.CC0 192.C002565.700      20
GRID      11106     10   0.CC0 343.5002564.000      20
GRID      11107     10  75.CC0 343.5C02564.C00      20
GRID      11108     10 319.0C0 343.5C02564.C00      20
GRID      11115     10 468.CC0 468.CC02558.800      20
GRID      11118     10   0.GC0 592.5002564.000      20
GRID      11119     10  75.C00 592.5002564.000      20
GRID      11120     10 319.000 592.5002564.000      20
GRID      11122     10   0.CC0 744.C002564.E00      20
GRID      11123     10 168.CC0 744.C002564.800      20
GRID      11125     10 468.CC0 744.C002564.E00      20
GRID      11300     10   0.000   0.C002777.750      20
GRID      11301     10 168.CC0   0.C002777.750      20
GRID      11302     10   0.CC0 192.C002777.750      20
GRID      11303     10 168.CC0 192.CC02777.750      20
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JOINT ANALYSIS -

FOLLOWING SECTIONS CONTAIN ANALYSES FOR NEW & CHANGED-UP MEMBERS.

BOLT ALLOWABLES ARE TAKEN FROM 'MANUAL OF STEEL CONSTRUCTION (7TH ED.). 4-3/7.

WELD ANALYSES FROM SAME REFERENCE 4-66/68.

TABULAR SHEETS SHOWING JOINT SHEAR LOADS USE THE METHOD GIVEN ON THE SHEETS IMMEDIATELY FOLLOWING.

FORM MAF/MMA 35-016-04/74
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JOINT METHODOLOGY

- Step 3—Calculate Δ_L

(1) $\frac{Pe\ (e + a)}{Wt_\ell}\left[\frac{3.2}{a} + \frac{4e}{t_\ell^2}\right](10^{-5})$

$= \frac{6,000}{3.38}\ \frac{(0.90)\ (0.90 + 0.71)}{0.376}$

$\left[\frac{3.2}{0.71} + \frac{4\ (0.90)}{(0.376)^2}\right]\ (10^{-5}) = 2.05$

(2) Because only the fitting is being considered, let K = 0

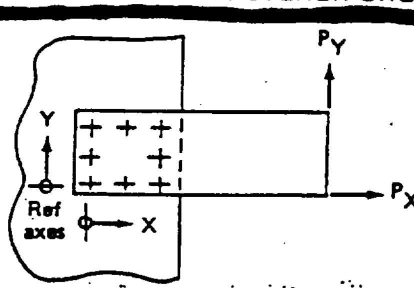
(3) $\frac{t_\ell}{D} = \frac{0.376}{0.375} = 1$

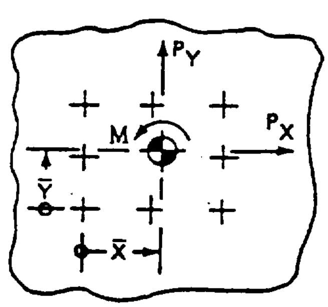
(4) From Fig. 30.2.2-1, $\Delta_L = 0.021$

- Step 4—Calculate Δ.

$\Delta = \Delta_L + \Delta_B = 0.021 + 0.0039 = 0.025$

30.3 ECCENTRIC LOAD ON FASTENER GROUPS





n fasteners of various diameters D
X and P_X: + to right
Y and P_Y: + up
M: + counterclockwise

Make tabular solution:

$\bar{X} = \frac{\Sigma DX}{\Sigma D};\ \bar{Y} = \frac{\Sigma DY}{\Sigma D}$

Fast. No.	X	Y	D	DX	DY	DX^2	DY^2
1							
2							
$\tilde{n}$							
Summations →			ΣD	ΣDX	ΣDY	ΣDX^2	ΣDY^2

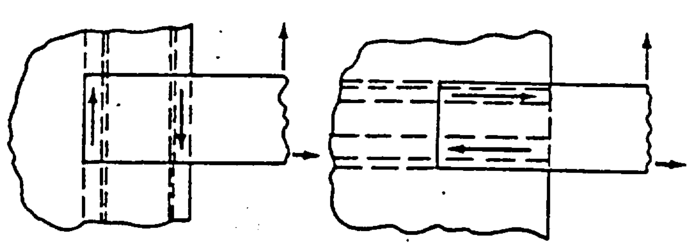
Compute moment about group centroid ($\bar{X}, \bar{Y}$)

$J = \Sigma DX^2 + \Sigma DY^2 - \bar{X}\ \Sigma DX - \bar{Y}\ \Sigma DY$

The load transferred by the first fastener:

$$F_i = D_i\left\{\left[\frac{P_Y}{\Sigma D} + \frac{M(X_i - \bar{X})}{J}\right]^2 + \left[\frac{P_X}{\Sigma D} - \frac{M(Y_i - \bar{Y})}{J}\right]^2\right\}^{1/2}$$

Assume that all fasteners are bearing critical, and assume constant thicknesses. The tabular procedure assumes elasticity; additional capacity is available for bearing critical fasteners only. Assume sheet yielding at the most critical fastener. Distribute additional external loading to the non-critical fasteners. If either member is significantly stiffer in one direction than in the other, loads will increase in the stiffer direction. It is generally conservative to neglect the other component, except as required for equilibrium.



Redistribution tendency
(adds other loads for equilibrium)

ARTIN MARIETTA
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JOINT METHODOLOGY – CONT'D

PROGRAM

	A	B	C	D	E	F	G	H	I	J
1	FASTNO	X	Y	DIA	SUMD	SUMDX	SUMDY	SUMDX2	SUMDY2	F
2	1				=SUM(D2:D17)	=SUM(D2:D17*B2:B17)	=SUM(D2:D17*C2:C17)	=SUM(D2:D17*B2:B17*B2:B17)	=SUM(D2:D17*C2:C17*C2:C17)	=D2*((E11+G11*(B2-E5))^2+(F11-G11*(C2-F5))^2)^0.5
3	2									=D3*((E11+G11*(B3-E5))^2+(F11-G11*(C3-F5))^2)^0.5
4	3				XBAR	YBAR	J			=D4*((E11+G11*(B4-E5))^2+(F11-G11*(C4-F5))^2)^0.5
5	4				=F2/E2	=G2/E2	=H2+I2-E5*F2-F5*G2			=D5*((E11+G11*(B5-E5))^2+(F11-G11*(C5-F5))^2)^0.5
6	5									=D6*((E11+G11*(B6-E5))^2+(F11-G11*(C6-F5))^2)^0.5
7	6				PX	PY	M			=D7*((E11+G11*(B7-E5))^2+(F11-G11*(C7-F5))^2)^0.5
8	7									=D8*((E11+G11*(B8-E5))^2+(F11-G11*(C8-F5))^2)^0.5
9	8									=D9*((E11+G11*(B9-E5))^2+(F11-G11*(C9-F5))^2)^0.5
10	9				PY/SD	PX/SD	M/J			=D10*((E11+G11*(B10-E5))^2+(F11-G11*(C10-F5))^2)^0.5
11	10				=F8/E2	=E8/E2	=G8/G5			=D11*((E11+G11*(B11-E5))^2+(F11-G11*(C11-F5))^2)^0.5
12	11									=D12*((E11+G11*(B12-E5))^2+(F11-G11*(C12-F5))^2)^0.5
13	12									=D13*((E11+G11*(B11-E5))^2+(F11-G11*(C13-F5))^2)^0.5
14	13									=D14*((E11+G11*(B14-E5))^2+(F11-G11*(C14-F5))^2)^0.5
15	14									=D15*((E11+G11*(B15-E5))^2+(F11-G11*(C15-F5))^2)^0.5
16	15									=D16*((E11+G11*(B16-E5))^2+(F11-G11*(C16-F5))^2)^0.5
17	16									=D17*((E11+G11*(B17-E5))^2+(F11-G11*(C17-F5))^2)^0.5

MARTIN MARIETTA
MICHOUD OPERATIONS

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JOINT METHODOLOGY

SAMPLE OUTPUT

	A	B	C	D	E	F	G	H	I	J
1	FAST NO	X	Y	DIA	SUMD	SUMDX	SUMDY	SUMDX2	SUMDY2	F
2	1.0	0.0	0.0	1.0	6.0	18.0	9.0	90.0	27.0	6924.6
3	2.0	3.0	0.0	1.0						6928.3
4	3.0	6.0	0.0	1.0	XBAR	YBAR	J			6935.6
5	4.0	0.0	3.0	1.0	3.0	1.5	49.5			6766.4
6	5.0	3.0	3.0	1.0						6770.2
7	6.0	6.0	3.0	1.0	PX	PY	M			6777.7
8	7.0				41070.0	1450.0	2610.0			0.0
9	8.0									0.0
10	9.0				PY/SD	PX/SD	M/J			0.0
11	10.0				241.7	6845.0	52.7			0.0
12	11.0									0.0
13	12.0									0.0
14	13.0									0.0
15	14.0									0.0
16	15.0									0.0
17	16.0									

JOINTS – ELEV 115

ELEMENTS $\boxed{162 \\ 163 \\ 166 \\ 167}$ $2\frac{1}{2} \times 2\frac{1}{2} \times \frac{1}{4}$

SAY 4 - 3/4" IN 3/8 PLATE

$P_{MAX} = 16460$
$S_{MAX} = 51$
$M_{MAX} = 2620$

$P_{BOLT\,MAX} = 4125$. $P_{ALL} = 13700$ $R = .3$

ELEMENTS $\boxed{164 \\ 168}$ $P_{MAX} = 52660$
$S_{MAX} = -$
$M = 877$

$P/BOLT = 52660/4 = 13165$. $R = .96$.

SAY 5 BOLTS, $P/BOLT = 10530$ $R = 10530/13700 = .77$

OR SAY 6 / $2\frac{1}{2}$ FOR 162-167

$aL = 2620/16460 = .16$ $KL = 2.5$ $K = 2.5/6 = .42$
$a = .16/6 = .03$.

$C = 1.51$
SAY $C = 1.0$

$P = CC_1DL$ $D = P/CC_1L$
$= 16.46/1.51(6) = 1.82$

FOR $2 \times \frac{5}{16}$, $R = .18$

FOR 164, 168 TRY SAME MECHANISM
$C = 1.51$
$D = 52.66/1.51(6) = 5.8$ $2 \times \frac{5}{16}$ $R = .58$

Joints - Elev 115 - Bolt Loads

ECC BOLT GRP

	A	B	C	D	E	F	G	H	I	J
1	FAST NO	X	Y	DIA	SUMD	SUMDX	SUMDY	SUMDX2	SUMDY2	F
2	1.0	0.0	0.0	1.0	4.0	18.0	0.0	126.0	0.0	4122.5
3	2.0	3.0	0.0	1.0						4115.7
4	3.0	6.0	0.0	1.0	XBAR	YBAR	J			4116.2
5	4.0	9.0	0.0	1.0	4.5	0.0	45.0			4124.2
6	5.0									0.0
7	6.0				PX	PY	M			0.0
8	7.0				16460.0	51.0	2620.0			0.0
9	8.0									0.0
10	9.0				PY/SD	PX/SD	M/J			0.0
11	10.0				12.8	4115.0	58.2			0.0
12	11.0									0.0
13	12.0									0.0
14	13.0									0.0
15	14.0									0.0
16	15.0									0.0
17	16.0									

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ELEV 115 - MEMBER LOADS

	A	B	C	D	E	F	G	H	I
1					EL 115				
2	ELEMENT	MA1	MA2	MB1	MB2	S1	S2	P	T
3	153	-55036	1607	56082	-1178	-661	17	-1063	2
4	154	-14379	3657	23724	1716	-295	24	41047	-12
5	155	26606	4691	-19565	5336	270	14	-46472	-12
6	156	-657	-1894	-209	3612	-4	-31	3751	-8
7	157	100399	5410	-67685	0	1697	55	661	15
8	158	211620	10727	-187301	5262	4030	55	109740	11
9	159	108511	-1819	-79084	8079	1876	-69	144662	-36
10	160	-48876	0	80955	1699	-759	-10	2590	-21
11	161	113438	39797	104022	38845	874	16	-55179	-3
12	162	-2261	0	2111	-180	-44	2	15715	-1
13	163	309	0	-33	0	2	0	16457	1
14	164	412	0	858	0	-4	0	52660	-2
15	165	-486252	43022	575799	-91485	-10728	1359	-79728	-75
16	166	2620	-178	-2419	0	51	-2	16271	1
17	167	202	0	251	0	-1	0	16094	1
18	168	399	0	877	0	-4	0	52386	2
19	169	574062	-91666	-484373	42587	10691	-1356	-79588	75
20	170	100298	-5911	-67076	0	1690	-60	679	-11
21	171	212859	-11738	-188305	-5767	4052	-60	109704	-5
22	172	115268	2583	-86800	-8922	2021	86	144256	28
23	173	-49185	0	81304	2409	-763	-14	2580	21
24	174	-224	3713	-656	-1931	4	32	3906	8
25	175	-55129	-1105	56256	-912	-663	11	-1318	-2
26	176	-16157	-3845	25574	-1782	-323	-26	41098	14
27	177	26306	-4797	-19427	-5495	267	-15	47050	12

MARTIN MARIETTA
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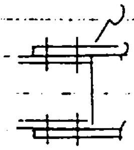
JOINTS - ELEV 125

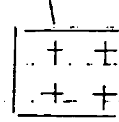
ELEMENTS 258 272 297 THESE ELEMENTS UNCHANGED
259 282 298
260 299
261 5250
262 5251
263 5252

BLANKETING LOADS, $P_{max} = 20810$
$S_{1max} = 3730$
$S_{2max} = 77$
$M_{1max} = 364,620$
$M_{2max} = 7610$

12" DEEP BEAMS.

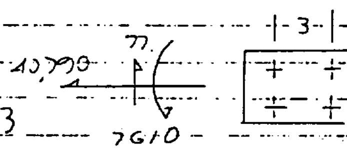
1/2" JOINT PLATE. 4-1"Ø



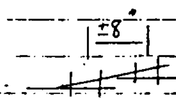


P_{max} (JOINT PLATE & FLANGE) $\doteq \frac{364620}{12} + \frac{20810}{2} = 40790$ lb.

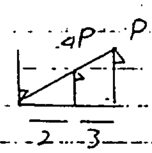
$P_{BOLT\ max(shear)} = 10850$ lb (1)



$P_{max} = 17,280$ - $R_s = 10850/17280 = .63$



PRYING FROM SHEAR
TAKE $M = \frac{3730(8)}{2} = 14,920.$



$14920 = 2(5P + 2(.4P)) = 11.6P.$
$P = 1290.$
$R_{T\,BOLT} = 1290/31400 = .04$

$R_{MAX} \doteq .63$

FORM MAF/MMA 35-016-04/74
NASA-MSFC-MAF

ORIGINAL PAGE IS
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JOINTS - ELEV 125

NEW & RECONNECTED I BEAMS: 273 283
274 284
275 5261
276 285
277 286
278 287
279 288

BLANKETING:

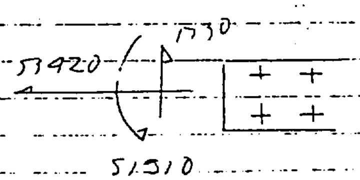
$P_{max} = 32,240$
$S_{1\,max} = 10140$
$S_{2\,max} = 1730$
$M_{1\,max} = 447560$
$M_{2\,max} = 51,910$

TRY SAME 4 - 1" ø BOLTS & 1/2" JOINT PLATES

P_{max} (JOINT PLATE & FLANGE) $\cong 447,560/12 + 32,240/2 = 53,420$ lb.

$P_{bolt\,max}$ (SHEAR) $= 18310$ (2)

$R_S > 1.0$



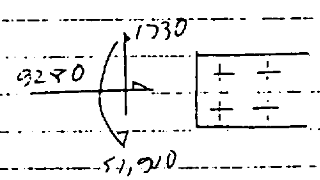
SEPARATING OUT HIGH M2 CONDITIONS:

EL 277
285

$P_{max} = 6170$
$S_{1\,max} = 5610$
$S_{2\,max} = 1730$
$M_{1\,max} = 74320$
$M_{2\,max} = 51910$

P_{max} (JOINT PLATE & FLANGE) $\cong 74320/12 + 6170/2 = 9280$

$P_{bolt\,max}$ (SHEAR) $= 8180$ (3)



PAIRING BOLT SHEAR

$R_{S\,bolt} \cong 8180/17260 = .47$

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JOINTS – ELEV 125

SEPARATING OUT HIGH M_1 CONDITIONS

EL 273 $P_{MAX} = 28630$

275 $S_{1MAX} = 10140$

283 $S_{2MAX} = 864$

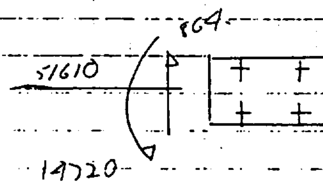
5261 $M_{1MAX} = 447560$

$M_{2MAX} = 14720$

P_{MAX} (JOINT PLATE & FLANGE) $\doteq \dfrac{447,560}{12} + \dfrac{28630}{2} = 51610$

$P_{BOLT\ MAX\text{-}SHEAR} = 14,200$ (4)

$R_s = .82$



PRYING FROM S1

FROM PREVIOUS, $P_T = 1290 \times 10140/3730 = 3510$

$R_T = 3510/31400 = .11$ $R_{MS} = (.82^2 + .11^2)^{1/2} = .83$

REMAINING ELEMENTS. $P_{MAX} = 32240$

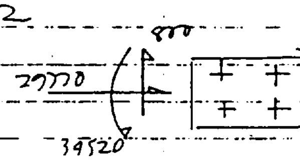
$S_{1MAX} = 4540$

$S_{2MAX} = 800$

$M_{1MAX} = 163,780$

$M_{2MAX} = 34,520$

P_{MAX} (JOINT PLATE & FLANGE) $\doteq \dfrac{163780}{12} + \dfrac{32,240}{2} = 29,770$



$P_{BOLT\ MAX\ SHEAR} = 11360$ (5)

$R_{MS} \doteq R_s = 11360/17260 = .66$

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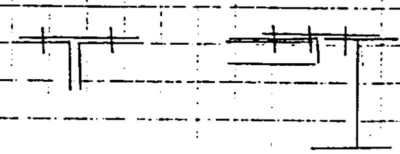
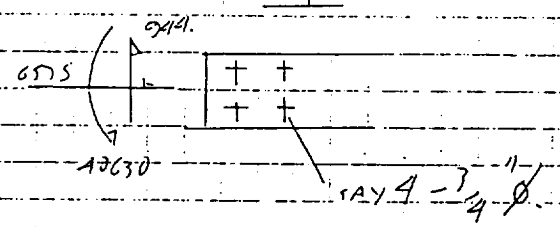
JOINTS - ELEV 125

ELEMENTS # 8017
8018
8019
8020

$P_{MAX} = 6575$
$S2_{MAX} = 944$
$M2_{MAX} = 40630$



$P_{S\ BOLT\ MAX\ SHEAR} = 6,200$ (c)



FOR 3/4" BOLTS, SAY 3/8" PLATE

$P_{ALL} = 9720$

$R = 6200/9720 = .64$

ARTIN MARIETTA
ICHOUD OPERATIONS

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JOINTS - ELEV 125

BOLT LOADS (1)

①	A	B	C	D	E	F	G	H	I	J
1	FAST NO	X	Y	DIA	SUMD	SUMDX	SUMDY	SUMDX2	SUMDY2	F
2	1.0	0.0	0.0	1.0	4.0	6.0	6.0	18.0	18.0	9583.1
3	2.0	3.0	0.0	1.0						9585.6
4	3.0	0.0	3.0	1.0	XBAR	YBAR	J			10849.1
5	4.0	3.0	3.0	1.0	1.5	1.5	18.0			10851.4
6	5.0									0.0
7	6.0				PX	PY	M			0.0
8	7.0				-40790.0	77.0	7610.0			0.0
9	8.0									0.0
10	9.0				PY/SD	PX/SD	M/J			0.0
11	10.0				19.3	-10197.5	422.8			0.0
12	11.0									0.0
13	12.0									0.0
14	13.0									0.0
15	14.0									0.0
16	15.0									0.0
17	16.0									0.0

ARTIN MARIETTA
ICHOUD OPERATIONS

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JOINTS - ELEV 125

BOLT LOADS (2)

(2)	A	B	C	D	E	F	G	H	I	J
1	FAST NO	X	Y	DIA	SUMD	SUMDX	SUMDY	SUMDX2	SUMDY2	F
2	1.0	0.0	0.0	1.0	4.0	6.0	6.0	18.0	18.0	9832.8
3	2.0	3.0	0.0	1.0						10206.3
4	3.0	0.0	3.0	1.0	XBAR	YBAR	J			18104.4
5	4.0	3.0	3.0	1.0	1.5	1.5	18.0			18309.9
6	5.0									0.0
7	6.0				PX	PY	M			0.0
8	7.0				-53420.0	1730.0	51910.0			0.0
9	8.0									0.0
10	9.0				PY/SD	PX/SD	M/J			0.0
11	10.0				432.5	-13355.0	2883.9			0.0
12	11.0									0.0
13	12.0									0.0
14	13.0									0.0
15	14.0									0.0
16	15.0									0.0
17	16.0									

ARTIN MARIETTA
HOUD OPERATIONS

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JOINTS - ELEV 125

BOLT LOADS (3)

(3)	A	B	C	D	E	F	G	H	I	J
1	FAST NO	X	Y	DIA	SUMD	SUMDX	SUMDY	SUMDX2	SUMDY2	F
2	1.0	0.0	0.0	1.0	4.0	6.0	6.0	18.0	18.0	7702.3
3	2.0	3.0	0.0	1.0						8173.7
4	3.0	0.0	3.0	1.0	XBAR	YBAR	J			4379.7
5	4.0	3.0	3.0	1.0	1.5	1.5	18.0			5163.8
6	5.0									0.0
7	6.0				PX	PY	M			0.0
8	7.0				9280.0	1730.0	51910.0			0.0
9	8.0									0.0
10	9.0				PY/SD	PX/SD	M/J			0.0
11	10.0				432.5	2320.0	2883.9			0.0
12	11.0									0.0
13	12.0									0.0
14	13.0									0.0
15	14.0									0.0
16	15.0									0.0
17	16.0									

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JOINTS - ELEV 125

BOLT LOADS (4)

4	A	B	C	D	E	F	G	H	I	J
1	FAST NO	X	Y	DIA	SUMD	SUMDX	SUMDY	SUMDX2	SUMDY2	F
2	1.0	0.0	0.0	1.0	4.0	6.0	6.0	18.0	18.0	11719.5
3	2.0	3.0	0.0	1.0						11764.6
4	3.0	0.0	3.0	1.0	XBAR	YBAR	J			14165.3
5	4.0	3.0	3.0	1.0	1.5	1.5	18.0			14202.6
6	5.0									0.0
7	6.0				PX	PY	M			0.0
8	7.0				-51610.0	864.0	14720.0			0.0
9	8.0									0.0
10	9.0				PY/SD	PX/SD	M/J			0.0
11	10.0				216.0	-12902.5	817.8			0.0
12	11.0									0.0
13	12.0									0.0
14	13.0									0.0
15	14.0									0.0
16	15.0									0.0
17	16.0									

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JOINTS - ELEV 125

BOLT LOADS (5)

5	A	B	C	D	E	F	G	H	I	J
1	FAST NO	X	Y	DIA	SUMD	SUMDX	SUMDY	SUMDX2	SUMDY2	F
2	1.0	0.0	0.0	1.0	4.0	6.0	6.0	18.0	18.0	11259.5
3	2.0	3.0	0.0	1.0						11361.2
4	3.0	0.0	3.0	1.0	XBAR	YBAR	J			5833.7
5	4.0	3.0	3.0	1.0	1.5	1.5	18.0			6027.7
6	5.0									0.0
7	6.0				PX	PY	M			0.0
8	7.0				32240.0	800.0	34520.0			0.0
9	8.0									0.0
10	9.0				PY/SD	PX/SD	M/J			0.0
11	10.0				200.0	8060.0	1917.8			0.0
12	11.0									0.0
13	12.0									0.0
14	13.0									0.0
15	14.0									0.0
16	15.0									0.0
17	16.0									

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JOINTS - ELEV. 125

BOLT LOADS (6)

6	A	B	C	D	E	F	G	H	I	J
1	FAST NO	X	Y	DIA	SUMD	SUMDX	SUMDY	SUMDX2	SUMDY2	F
2	1.0	0.0	0.0	1.0	4.0	6.0	6.0	18.0	18.0	5934.5
3	2.0	3.0	0.0	1.0						6197.9
4	3.0	0.0	3.0	1.0	XBAR	YBAR	J			3599.5
5	4.0	3.0	3.0	1.0	1.5	1.5	18.0			4019.0
6	5.0									0.0
7	6.0				PX	PY	M			0.0
8	7.0				6575.0	944.0	40630.0			0.0
9	8.0									0.0
10	9.0				PY/SD	PX/SD	M/J			0.0
11	10.0				236.0	1643.8	2257.2			0.0
12	11.0									0.0
13	12.0									0.0
14	13.0									0.0
15	14.0									0.0
16	15.0									0.0
17	16.0									

ARTIN MARIETTA
IICHOUD OPERATIONS

VC DATE 3/30 SUBJECT PFBTS SHEET ____ OF 15-11

WORK PACKAGE ____

PROVED ____ DATE ____

PROVED ____ DATE ____ REV ____ DATE ____

JOINT - ELEV 12.5

ELEMENT LOADS - CONT'D

	A	B	C	D	E	F	G	H	I
45	296	315462	-18532	-274595	12580	3160	-155	-29352	-348
46	297	91570	-1416	-133976	-620	1095	-10	10912	-12
47	298	-213579	-1629	202256	2301	-2189	-21	-13327	-19
48	299	304491	-689	-361088	-976	3669	9	8330	-15
49	8017	0	-40627	0	26454	0	-944	-5312	-15
50	8018	0	18142	0	-23542	0	382	-6572	-28
51	8019	0	-17890	0	23418	0	-378	-6573	-150
52	8020	0	38193	0	-21262	0	846	-5283	15
53	5250	-28630	-1908	139824	2320	-823	-21	20812	9
54	5251	23537	7611	24413	-6106	-62	77	-18095	12
55	5252	-177169	-1333	61946	-2757	-972	8	-9463	-22
56	5253	322710	71192	-394926	-28587	3987	564	-49724	392
57	5254	-205759	4398	217102	-5824	-2517	61	-4527	6
58	5255	-53474	-4334	44716	4213	-428	-66	45452	194
59	5256	109125	-12274	-68031	5079	1036	-101	42306	-172
60	5261	1325200	-27311	447557	3606	9463	-306	28632	-12715

ORM MAF/MMA 35-016-04/74
ASA-MSFC-MAF

ARTIN MARIETTA
ICHOUD OPERATIONS

VC DATE 3/30 SUBJECT PFBTS. SHEET ___ OF 15-12

WORK PACKAGE

ROVED DATE

ROVED DATE REV DATE

JOINT - ELEV. 12

ELEMENT LOADS

	A	B	C	D	E	F	G	H	I
1									
2	ELEMENT	MA1	MA2	MB1	EL 125 MB2	S1	S2	P	T
3	254	-205535	-4447	214170	5890	-2498	-62	-4406	-5
4	255	-54613	3930	40437	-3099	-425	54	46468	-194
5	256	111323	12725	-71606	-5437	1070	106	41129	172
6	257	-265572	11088	319162	-18889	-3117	159	-32616	348
7	258	-93943	1721	-135520	-611	1115	11	10214	12
8	259	-214092	1675	206009	-2511	-2207	22	-12094	19
9	260	-364622	-1358	311277	986	-3731	-13	8273	15
10	261	-30913	1912	140885	-2122	-835	20	20277	-10
11	262	26347	-6007	21828	7488	80	-76	-17572	-12
12	263	-175463	1442	61470	2631	-963	-7	-10176	22
13	264	-395315	-28376	323103	71565	-4000	-565	-48293	-388
14	265	65824	3773	-39629	0	1076	39	-66240	-83
15	266	-131958	-11632	-37659	4598	-1626	-280	-55884	-63
16	267	461016	-11386	-210261	-11637	16373	-536	-110198	-65
17	268	47834	-17171	-72833	-27637	2943	753	-122305	-154
18	269	69845	9370	35482	-17173	627	450	-141019	-156
19	270	-46512	0	83266	16470	-757	-96	-117468	155
20	271	379629	-18906	-365976	-38132	7531	407	-36957	57
21	272	8959	-1723	-39052	3858	343	-40	-7625	7
22	273	358817	0	473754	-80249	-1354	811	20488	7218
23	274	97977	-2417	-160990	2724	1850	-35	-22798	37
24	275	393751	14719	1379140	-25846	-10143	386	27172	12253
25	276	381944	-12783	48629	6203	4271	-238	-22796	47
26	277	69171	51911	390891	-53413	-5605	1726	-5409	-16
27	278	-38224	7485	248424	-7773	-2473	130	-3409	-58
28	279	263834	-30688	61053	34419	3104	-796	-31870	84
29	280	164878	53904	-84716	-67012	2521	1221	-53419	-676
30	281	-367075	-38131	373923	-19005	-7484	406	-34413	-63
31	282	10963	1673	-41333	-3862	373	39	-6944	-7
32	283	471563	-85534	370020	0	1209	-864	20007	-7159
33	284	97877	2459	-163782	-2957	1878	37	-22665	-36
34	285	74317	-51168	391408	52587	-5529	-1701	-6169	13
35	286	385113	14530	32539	-7114	4536	270	-23645	-51
36	287	263828	30626	58513	-34522	3138	797	-32243	20
37	288	-37627	-7546	248252	7792	-2469	-131	-3493	-16
38	289	-84600	-67298	167071	53752	-2542	-1223	-54824	675
39	290	63362	-2016	-38114	0	1025	-20	-66586	81
40	291	-130942	-11465	-40746	-7079	-1582	313	-55693	64
41	292	454915	11579	-209113	-11469	16196	562	-109933	65
42	293	68049	18514	-101857	31427	4144	-809	-122495	152
43	294	59587	-11019	56245	18512	146	-501	-140242	154
44	295	-46170	0	82432	-17052	-750	100	-117080	-154

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MARTIN MARIETTA
MICHOUD OPERATIONS

JC DATE 3/30 SUBJECT PFBTS SHEET ____ OF 16-1

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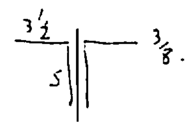
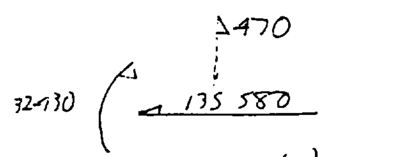
JOINTS – ELEV 157

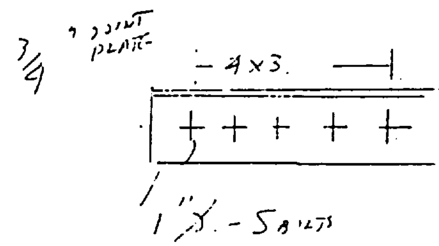
ELEMENTS 803 804 (TRUSS LOWER
805 806 CHORDS)

ENVELOPING, P = 135,580
S_1 = 470
S_2 = –
M_1 = 32,430
M_2 = 500

ON.





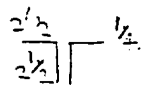


TAKE M_{TOT} = 32430 + 470(12) = 37730

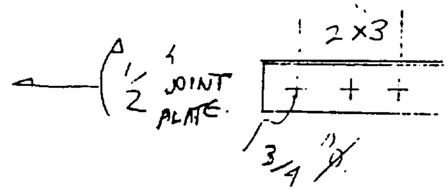
$P_{BOLT\,MAX}$ = 27240 ①

P_{ALL} (DOUBLE S) = 34520 R = 27240 / 34520 = .79

ELEMENTS 561 & 565 ARE

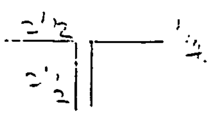


P = 40110
S_1 = –
S_2 = –
M_1 = 660



$P_{BOLT\,MAX}$ = 13370 ②
P_{ALL} = 18220 R = .71

ELEMENTS 560 564



P = 25110
S_1 = 38
S_2 = –
M_1 = 2440
M_2 = 510

MAKE SAME AS 561 & 565

FORM MAF/MMA 35-016-04/74
NASA-MSFC-MAF

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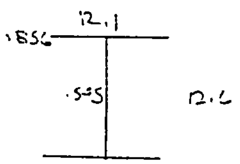
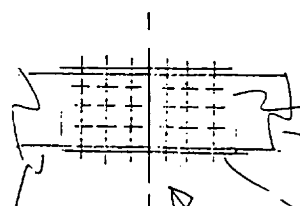
JOINTS – ELEV 157

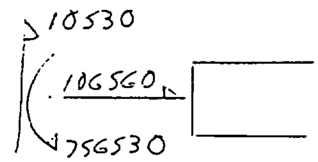
ELEMENTS 563 + 567

12 WF 92
$A = 27.1$
$I_1 = 789$
$I_2 = 256$

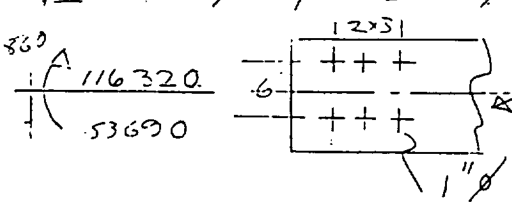


$P = 106560$
$S_1 = 10530$
$S_2 = 860$
$M_1 = 756530$
$M_2 = 107380$

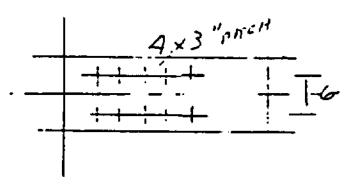




CHORD LOADS FROM P, M_1, M_2.
P_{MAX} ON CHORD $\doteq$ 106560/2 + 756,530/12 = 116,320
ON 6–1"Ø BOLTS
$P_{BOLT_{MAX}}$ = 21260



INCREASE TO 10 BOLTS:
P_{MAX}/BOLT = 12300 ③
P_{MAX} = 17260
R = 12300/17260 = .71



S_1 NO PROBLEM ON EXISTING WEB PLATE PATTERN.

SAY 1" SPLICE JOINT PLATE 12" EW. ON COMP. SIDE
f_c = 116,320/12 = 9680 PSI
f_b = 53690×6/12² = 2240 $f_{NET_{MAX}}$ = 11,930 PSI.
BEAM $f_{NET_{MAX}}$ = 106,560/27.1 + 756,530(6.3)/789 + 107,380(6.05)/256
= −12,510 PSI
WEB $f_{S_{AV}}$ = 10530/10.9(.545) = 1770 PSI.

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ARTIN MARIETTA
HOUD OPERATIONS

VC DATE 3/30 SUBJECT PFBTS SHEET ____ OF 16-3

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JOINTS - ELEV 157

BOLT LOADS (1)

(1)	A	B	C	D	E	F	G	H	I	J
1	FAST NO	X	Y	DIA	SUMD	SUMDX	SUMDY	SUMDX2	SUMDY2	F
2	1.0	0.0	0.0	1.0	5.0	30.0	0.0	270.0	0.0	27237.5
3	2.0	3.0	0.0	1.0						27148.7
4	3.0	6.0	0.0	1.0	XBAR	YBAR	J			27116.2
5	4.0	9.0	0.0	1.0	6.0	0.0	90.0			27140.1
6	5.0	12.0	0.0	1.0						27220.4
7	6.0				PX	PY	M			0.0
8	7.0				-135580.0	470.0	-37130.0			0.0
9	8.0									0.0
10	9.0				PY/SD	PX/SD	M/J			0.0
11	10.0				94.0	-27116.0	-412.6			0.0
12	11.0									0.0
13	12.0									0.0
14	13.0									0.0
15	14.0									0.0
16	15.0									0.0
17	16.0									

ARTIN MARIETTA
HOUD OPERATIONS

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ROVED ___ DATE ___ REV ___ DATE ___

JOINTS - ELEV 157

BOLT LOADS (2)

(2)	A	B	C	D	E	F	G	H	I	J
1	FAST NO	X	Y	DIA	SUMD	SUMDX	SUMDY	SUMDX2	SUMDY2	F
2	1.0	0.0	0.0	1.0	3.0	9.0	0.0	45.0	0.0	13370.5
3	2.0	3.0	0.0	1.0						13370.0
4	3.0	6.0	0.0	1.0	XBAR	YBAR	J			13370.5
5	4.0				3.0	0.0	18.0			0.0
6	5.0									0.0
7	6.0				PX	PY	M			0.0
8	7.0				40110.0		660.0			0.0
9	8.0									0.0
10	9.0				PY/SD	PX/SD	M/J			0.0
11	10.0				0.0	13370.0	36.7			0.0
12	11.0									0.0
13	12.0									0.0
14	13.0									0.0
15	14.0									0.0
16	15.0									0.0
17	16.0									0.0

JOINTS - ELEV 157

BOLT LOADS 3

3	A	B	C	D	E	F	G	H	I	J
1	FAST NO	X	Y	DIA	SUMD	SUMDX	SUMDY	SUMDX2	SUMDY2	F
2	1.0	0.0	0.0	1.0	10.0	60.0	30.0	540.0	180.0	11090.8
3	2.0	3.0	0.0	1.0						11047.2
4	3.0	6.0	0.0	1.0	XBAR	YBAR	J			11035.8
5	4.0	9.0	0.0	1.0	6.0	3.0	270.0			11056.5
6	5.0	12.0	0.0	1.0						11109.3
7	6.0	0.0	6.0	1.0	PX	PY	M			12278.6
8	7.0	3.0	6.0	1.0	116320.0	-860.0	-53690.0			12239.2
9	8.0	6.0	6.0	1.0						12228.9
10	9.0	9.0	6.0	1.0	PY/SD	PX/SD	M/J			12247.6
11	10.0	12.0	6.0	1.0	-86.0	11632.0	-198.9			12295.3
12	11.0									0.0
13	12.0									0.0
14	13.0									0.0
15	14.0									0.0
16	15.0									0.0
17	16.0									

ARTIN MARIETTA
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ELEV .157

MEMBER LOADS

		1 MA 2		1 MB 2		1 S 2		P	
	A	B	C	D	E	F	G	H	I
1	556	210390	-5340	-182454	0	4733	-64	1721	-186
2	557	236428	33503	-187817	-12801	3721	406	258357	-107
3	558	-158017	0	186534	33813	-2195	-215	1585	-108
4	559	174030	82879	134108	87891	1005	-50	-128336	10
5	560	-1837	0	2444	511	-38	-4	24056	2
6	561	168	0	662	0	-4	0	40110	0
7	563	-448450	-106223	752783	-48145	-10531	-853	-101906	118
8	564	2224	510	-1574	0	33	4	25113	-2
9	565	187	0	590	0	-3	0	38264	-1
10	567	756528	-48124	-405944	-107383	10197	864	-106563	-131
11	568	212668	-5434	-185001	0	4791	-65	1669	227
12	569	240127	-31566	-191355	-12481	3785	-383	261699	-74
13	570	-156197	0	186585	-31878	-2183	203	1525	128
14	577	282009	-12642	-244195	-5307	4616	-64	177011	-222
15	578	287094	-12640	-249627	-5177	4708	-65	178926	266
16	8003	31212	483	32427	0	-22	7	131718	16
17	8004	-29085	0	31212	483	-469	-4	131718	19
18	8005	-27357	0	31608	-497	-455	4	135582	-21
19	8006	31608	-497	31972	0	-8	-8	135582	-18

ARTIN MARIETTA
HOUD OPERATIONS

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ELEV 169 - CHECK OF BENDING ALLOW. VS. WEB SHEAR

AISI 1.10.5.2 :

$$F_v = \frac{F_y}{2.89}(C_v) \leq .4 F_y.$$

WHERE $K = 5.34 + \frac{4}{(\frac{a}{h})^2}$ $= 5.34$ FOR NO STIFFENERS.

FOR $\frac{F_y}{2.89}(C_v) = .4 F_y$, $C_v = 2.89(.4) = 1.156.$

FOR $C_v > .8$, $C_v = \frac{190}{h/t}\sqrt{\frac{K}{F_y}}$.

$\frac{h}{t} = \frac{190}{C_v}\sqrt{\frac{K}{F_y}}$ $K = 5.34$, $F_y = 36$ksi.

$\frac{h}{t} = \frac{190}{1.156}\sqrt{\frac{5.34}{36}} = 63.3.$

IE. WEB SHEAR ALLOWED UP TO .4 Fy (IE 14.5 ksi) FOR UNSTIFFENED BEAM PROVIDED $h/t \not> 63.3$.

IE. $h = 12$ $t \not< .19.$

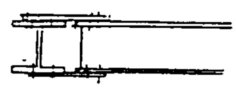
$h = 36$ $t \not< .57.$

1.10.7.

BENDING STRESS ALLOWABLE (BENDING IN PLANE OF WEB) = 22 ksi FOR $f_v/F_v \not> .6$, IE. UP TO $F_s = .6(14.5) = 8.7$ksi.

ELEV 169 – JOINTS.

CONSIDERING JOINTS TYPE 1
MEMBERS 658–663
698–699
5650–5653.

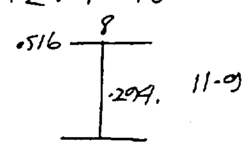


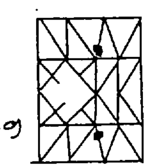
THESE MEMBERS NOT BEING REPLACED.

MEMBERS 660, 5650 HAVE LARGE M_1 VALUES

ENVELOPING; $P = 12460$
$S_1 = 8130$
$S_2 = 76$
$M_1 = 685{,}050$
$M_2 = 6720$

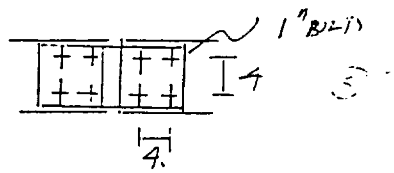
ON 12WF40





DIRECT FLANGE LOAD ≐ $12460/2 + 685050/11.38 = 66{,}430$
$f_{FLANGE} = 66430/8(.516) = 16090$
$M_2 = 6720/2$ ON $.516(8)^2/6$ I.E. $f = 610$ $f_{MAX} = 16{,}700$

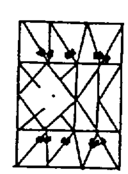
TAKE FLANGE PLATE GROUP AS



UNDER $\underset{\curvearrowleft 3360}{\xrightarrow{66430}}$

$P_{BOLT_{MAX}} = 16820$ (1) $R = 15{,}900/17260 = .97$
(1" A325-X PATTERNS)

REMAINING MEMBERS; ENVELOPING $P = 25330$ (REF #1).
$S_1 = 4700$
$S_2 = 86$
$M_1 = 429360$
$M_2 = 24480$



FLANGE LOAD $= 25330/2 + 429360/11.38 = 50390$

TAKE FLANGE PLATE AS ABOVE UNDER $\underset{\curvearrowleft 12240}{\xrightarrow{50390}}$

$P_{BOLT_{MAX}} = 13380$ (2) , $R = 13380/17260 = .78$
(1" A325-X PATTERNS)

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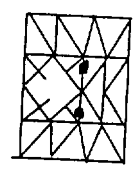
ELEV 169 - JOINTS (CONT'D)

2 S_1 EFFECTS SHALL ON BOLTS & 5/8" JOINT PLATE.

JOINTS TYPE (1)

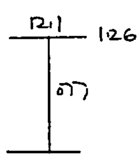
MEMBERS 674~6
679
684~6
688
8013~6

MEMBERS 675 & 685 (CROSSBEAM TO TRUSS)



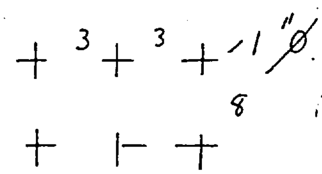
ENVELOPING; $P = 23590$ (REF #3)
$S_1 = 45550$
$S_2 = -$
$M_1 = 1,346,420$
$M_2 = 14460$

36 WF 194.

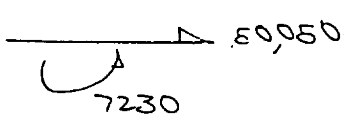


$P_{FLANGE} = 1,346,420/35.2 + 23,590/2 = 50,050$ LB

TAKE FLANGE PLATE GROUP AS:



WHERE



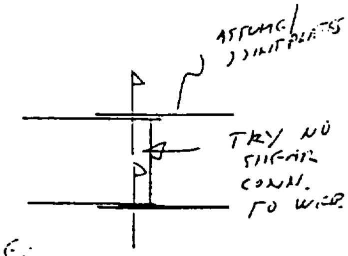
$P_{BOLT_{MAX}} = 8570$ LB. (3) $R_s = 8570/17260 = .50$

$f_{s\,WEB} = \dfrac{45550}{34 \times .77} = 1740$ psi

ELEV 169 - JOINTS (CONT'D)

3

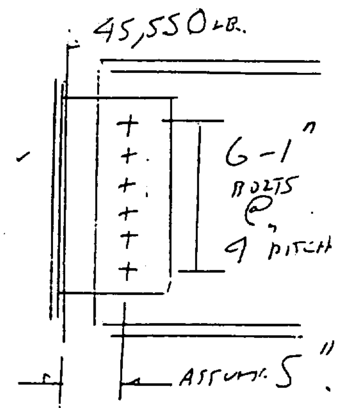
675 & 685 - CONT'D.



$S_1 = 45{,}550$ LB $= 22{,}780$/FLANGE.

ASSUME 5" EFFECTIVE BENDING ARM ON PLATE;
" 12" EFFECTIVE PLATE WIDTH

$$\frac{22780 \times 5 \times 6}{12 \times 1^2} = 56{,}950$$

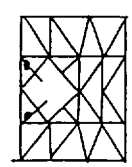


SUPPLY SHEAR CONN. TO WEB.

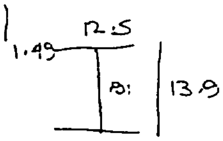
$P = 45{,}550$
$M = 5 \times 45{,}550 = 227{,}750$
P_{MAX} ON BOLT GROUP $= 13240$ (4)
$R = 13240/17260 = .77$

JOINTS TYPE (1)
MEMBERS 8013 & 8216 (SUPPORT BEAMS).

ENVELOPING : $P = 8390$
$S_1 = 34820$
$S_2 = 860$
$M_1 = 297500$
$M_2 = 41780$



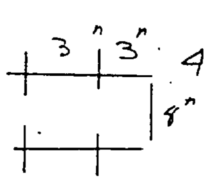
ON 12WF161

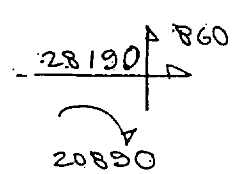


$f_{s\ WEB} = 34820/10.9(.91) = 3510$ PSI

$P_{FLANGE} = 8390/2 + 297{,}500/12.4 = 28190$

SAY 4-1" BOLTS UNDER





(5)

$P_{BOLT\ MAX} = 9000$ (5)
$P_{ALL} = 17{,}260$
$R = 9000/17260 = .52$

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ELEV 169 - JOINTS (CONT'D)

4 #8013 & #8016 (CONT'D)

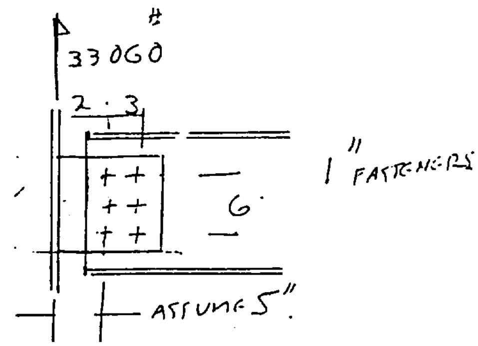
$S_1 = 34820^{\#}$

$M = 34820 \times 4.5 = 156,690$

$P_{BOLT\,MAX} = 14200$ (6)

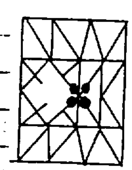
$P_{ALL} = 17,260$

$R = 14200/17260 = .82$



5
#674
677
684
687

ENVELOPING;
$P = 39810$
$S_2 = 80$
$M_2 = 6290$

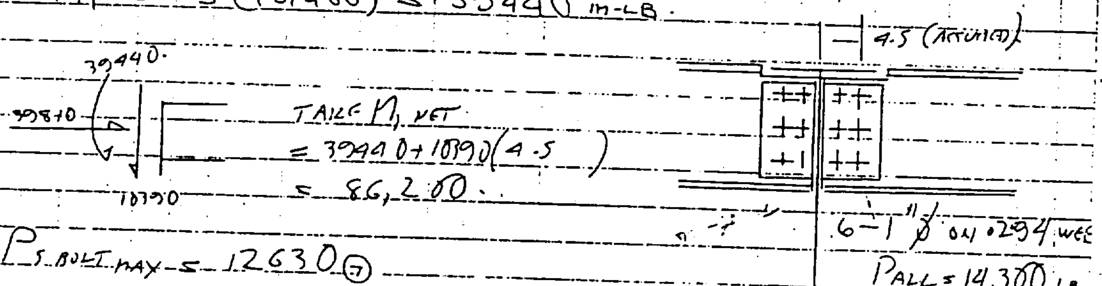


FROM PREVIOUS RUN WITH FIXED ENDS, $S_1 = 10390$
$M_1 = 131460$

WE ARE NOT PROVIDING FIXED END CONNECTIVITY, BUT ASSUME SOME TENDENCY FOR MOMENT REACTION THRU JOINT

USE $S_1 = 10390$

$M_1 = .3(131460) = 39440$ in-LB.



TAKE M_1 NET
$= 39440 + 10390(4.5)$
$= 86,200$

$P_{ALL} = 14,300$ LB. PER BOLT.

$P_{S\,BOLT\,MAX} = 12630$ (7)

$R_S = 12630/14300 = .88$

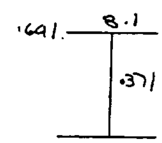
ELEV 169 - JOINTS (CONT'D)

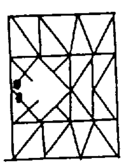
JOINT TYPE (2)

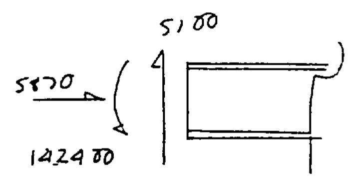
#678
#685

P = 5870
S_1 = 5100
S_2 = 320
M_1 = 142400
M_2 = 16420

ON 12WF50







ON SAME JOINT DESIGN AS PREVIOUS:

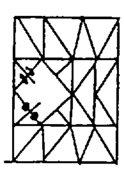
$$M_{HE} = 142400 - 5100(3 + 3.9) + 5870(5.4 - 3)$$
$$= 121,300$$

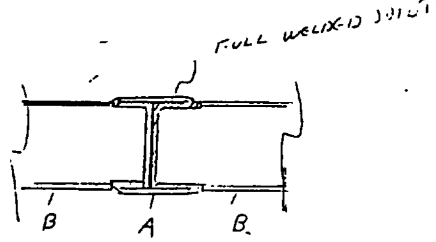
$P_{BOLT\ MAX}$ = 3060. R = SMALL.

JOINT TYPE (3)

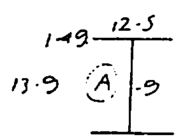
#678
679
688
689

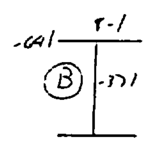
P = 70260
S_1 = 5100
S_2 = 1470
M_1 = 414240
M_2 = 62280





12W50. A = 14.7
I_1 = 395
I_2 = 56.4.

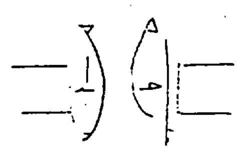




$$f_{FLANGE\ MAX} = \frac{70260}{14.7} + \frac{(414240)(6.1)}{395} + \frac{62280(4.05)}{56.4}$$
4780 6400 4470

= 15650 PSI

$f_{S\ AV}$ = 5100 / .371(12.2) = 1260 PSI



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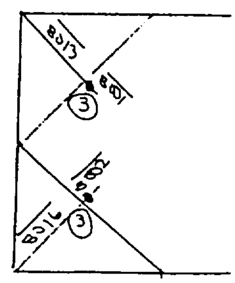
ELEV 163 - JOINTS (CONT'D)

7 #801 AT JOINTS (3).
#802



P = 0
S_1 = 221,840
S_2 = 0
M_1 = 3,485,570
M_2 = 0.

PER J. TOMBA: 12WF161 UNAVAILABLE. USE 12WF170

FLANGE - f = 3,485,570 (7) / 1650 = 14,790 psi

WEB. f_{AV} = 221,840 / 10.83 (.96) = 21,240 psi.

ADD DOUBLER PLATES TO WEB,

SAY 2 x .75.

t_{WEB} = .96 + 1.5 = 2.46.

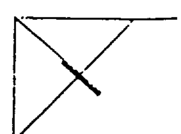
f_s = 21240 (.96/2.46) = 8290 psi.

8290 / 14500 = .57 ; NO BENDING ALLOWABLE REDUCTION REQUIRED

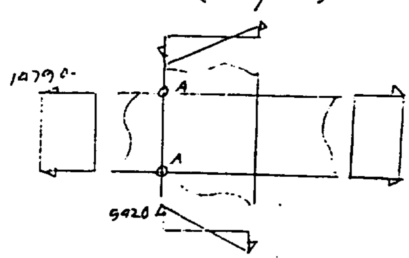
FLANGE UNDER M_1, f_b = 3,485,570(7) / 1650 = 14,790 psi.

FROM #678 - #685 LOAD PASSING THRU FLANGE, f_{max} = 23090 (.661/1.56) = 9420

12.6 1.56
14 .96
A = 50
I_1 = 1650
I_2 = 517.



AT A, $f_{s\,max}$ = ½ (14790 + 9420) = 12,100 psi.
≡ f_T = 24,200 psi. (MAX SHEAR STRESS THEORY).



I MAF/MMA 35-016-04/74
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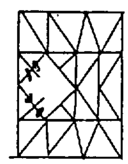
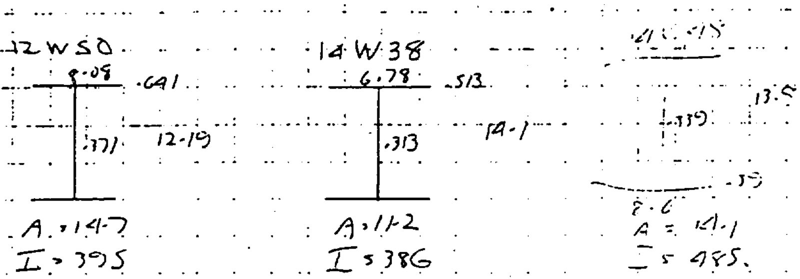
ELEV 169 - JOINTS (CONT'D)

ELEMENTS 678
679
688
689



CHANGING THESE FROM 12 W 50 TO 14 W 38 GIVES BETTER FIT WITH 12 W 170 SUPPORT BEAMS.

COMPARING



WITH 12 W 50, R VALUES ARE: # 678 .515
679 .617
688 .618
689 .514.

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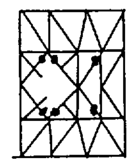
ELEV 169 – JOINTS (CONT'D)

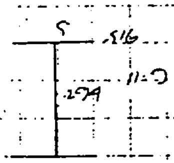
TYPE ① CONNS.
INSIDE TRUSS TO MAIN TRUSS CHORDS. — I BEAMS.

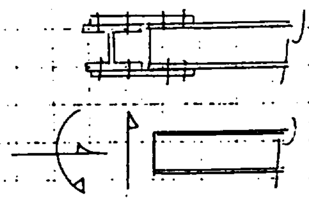
674
676
679
688
686
684

P_{MAX}: 70470 (REF #6)
S_1 = 8120
S_2 = 1470
M_1 = 325720
M_2 = 62460



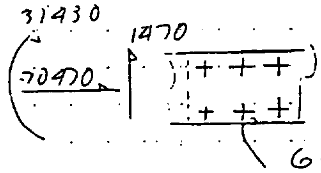
12 W 40





DIRECT FLANGE LOAD ≐ 70470/2 + 325720 / 11.4 = 63810

TAKE FLANGE PLATE GROUP AS



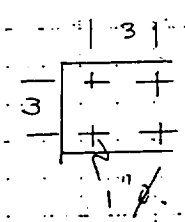
TAKE M_{TOTAL} = 3.12130 + 5(1470)
= 38,780

$P_{S\,BOLT\,MAX}$ = 13090 ⑧ R = 13090/17260 = .76

S_1 EFFECTS LOW.

8014
8015

F = 6060
S_2 = 810
M_2 = 35860



$P_{S\,BOLT\,MAX}$ = 5520 ⑨

R_S = 5520/17260 = .32

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?ROVED	DATE
REV	DATE

JOINTS – ELEV 169

BOLT LOADS – 1

1	A	B	C	D	E	F	G	H	I	J
1	FAST NO	X	Y	DIA	SUMD	SUMDX	SUMDY	SUMDX2	SUMDY2	F
2	1.0	0.0	0.0	1.0	4.0	8.0	8.0	32.0	32.0	16818.8
3	2.0	4.0	0.0	1.0						16818.8
4	3.0	0.0	4.0	1.0	XBAR	YBAR	J			16398.8
5	4.0	4.0	4.0	1.0	2.0	2.0	32.0			16398.8
6	5.0									0.0
7	6.0				PX	PY	M			0.0
8	7.0				66430.0		3360.0			0.0
9	8.0									0.0
10	9.0				PY/SD	PX/SD	M/J			0.0
11	10.0				0.0	16607.5	105.0			0.0
12	11.0									0.0
	12.0									0.0
14	13.0									0.0
15	14.0									0.0
16	15.0									0.0
17	16.0									

BOLT LOADS – 2

2	A	B	C	D	E	F	G	H	I	J
1	FAST NO	X	Y	DIA	SUMD	SUMDX	SUMDY	SUMDX2	SUMDY2	F
2	1.0	0.0	0.0	1.0	4.0	8.0	8.0	32.0	32.0	13384.4
3	2.0	4.0	0.0	1.0						13384.4
4	3.0	0.0	4.0	1.0	XBAR	YBAR	J			11857.2
5	4.0	4.0	4.0	1.0	2.0	2.0	32.0			11857.2
6	5.0									0.0
7	6.0				PX	PY	M			0.0
8	7.0				50390.0		12240.0			0.0
9	8.0									0.0
10	9.0				PY/SD	PX/SD	M/J			0.0
11	10.0				0.0	12597.5	382.5			0.0
12	11.0									0.0
3	12.0									0.0
4	13.0									0.0
15	14.0									0.0
16	15.0									0.0
17	16.0									

ELEV 169 - JOINTS (CONT'D)

BOLT LOADS - 3

3	A	B	C	D	E	F	G	H	I	J
1	FAST NO	X	Y	DIA	SUMD	SUMDX	SUMDY	SUMDX2	SUMDY2	F
2	1.0	0.0	0.0	1.0	6.0	18.0	9.0	90.0	27.0	8572.0
3	2.0	3.0	0.0	1.0						8560.8
4	3.0	6.0	0.0	1.0	XBAR	YBAR	J			8572.0
5	4.0	0.0	3.0	1.0	3.0	1.5	49.5			8134.4
6	5.0	3.0	3.0	1.0						8122.6
7	6.0	6.0	3.0	1.0	PX	PY	M			8134.4
8	7.0				50050.0		7230.0			0.0
9	8.0									0.0
10	9.0				PY/SD	PX/SD	M/J			0.0
11	10.0				0.0	8341.7	146.1			0.0
12	11.0									0.0
13	12.0									0.0
14	13.0									0.0
15	14.0									0.0
16	15.0									0.0
17	16.0									

BOLT LOADS - 4

4	A	B	C	D	E	F	G	H	I	J
1	FAST NO	X	Y	DIA	SUMD	SUMDX	SUMDY	SUMDX2	SUMDY2	F
2	1.0	0.0	0.0	1.0	6.0	0.0	45.0	0.0	495.0	13238.3
3	2.0	0.0	3.0	1.0						9998.8
4	3.0	0.0	6.0	1.0	XBAR	YBAR	J			7895.5
5	4.0	0.0	9.0	1.0	0.0	7.5	157.5			7895.5
6	5.0	0.0	12.0	1.0						9998.8
7	6.0	0.0	15.0	1.0	PX	PY	M			13238.3
8	7.0					45550.0	227750.0			0.0
9	8.0									0.0
10	9.0				PY/SD	PX/SD	M/J			0.0
11	10.0				7591.7	0.0	1446.0			0.0
12	11.0									0.0
13	12.0									0.0
14	13.0									0.0
15	14.0									0.0
16	15.0									0.0
17	16.0									

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ELEV 169 - JOINTS (CONT'D)

BOLT LOADS - 5

5	A	B	C	D	E	F	G	H	I	J
1	FAST NO	X	Y	DIA	SUMD	SUMDX	SUMDY	SUMDX2	SUMDY2	F
2	1.0	0.0	0.0	1.0	4.0	6.0	6.0	18.0	18.0	5655.6
3	2.0	3.0	0.0	1.0						5521.7
4	3.0				XBAR	YBAR	J			0.0
5	4.0	0.0	3.0	1.0	1.5	1.5	18.0			9003.3
6	5.0	3.0	3.0	1.0						8919.8
7	6.0				PX	PY	M			0.0
8	7.0				28190.0	860.0	-20890.0			0.0
9	8.0									0.0
10	9.0				PY/SD	PX/SD	M/J			0.0
11	10.0				215.0	7047.5	-1160.6			0.0
12	11.0									0.0
13	12.0									0.0
14	13.0									0.0
15	14.0									0.0
16	15.0									0.0
17	16.0									

BOLT LOADS - 6

6	A	B	C	D	E	F	G	H	I	J
1	FAST NO	X	Y	DIA	SUMD	SUMDX	SUMDY	SUMDX2	SUMDY2	F
2	1.0	0.0	0.0	1.0	6.0	9.0	18.0	27.0	90.0	9554.8
3	2.0	0.0	3.0	1.0						1055.2
4	3.0	0.0	6.0	1.0	XBAR	YBAR	J			9554.8
5	4.0	3.0	0.0	1.0	1.5	3.0	49.5			14195.6
6	5.0	3.0	3.0	1.0						10551.5
7	6.0	3.0	6.0	1.0	PX	PY	M			14195.6
8	7.0					34820.0	156690.0			0.0
9	8.0									0.0
10	9.0				PY/SD	PX/SD	M/J			0.0
11	10.0				5803.3	0.0	3165.5			0.0
12	11.0									0.0
13	12.0									0.0
14	13.0									0.0
15	14.0									0.0
16	15.0									0.0
17	16.0									

ARTIN MARIETTA
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JC DATE 3/30 SUBJECT PFBTS SHEET ____ OF 17-13

WORK PACKAGE

ROVED ____ DATE ____

ROVED ____ DATE ____ REV ____ DATE ____

ELEV 165 - JOINTS (CONT'D)

BOLT LOADS - (7)

(7)	A	B	C	D	E	F	G	H	I	J
1	FAST NO	X	Y	DIA	SUMD	SUMDX	SUMDY	SUMDX2	SUMDY2	F
2	1.0	0.0	0.0	1.0	6.0	9.0	18.0	27.0	90.0	11891.9
3	2.0	0.0	3.0	1.0						6693.2
4	3.0	0.0	6.0	1.0	XBAR	YBAR	J			1663.0
5	4.0	3.0	0.0	1.0	1.5	3.0	49.5			12629.7
6	5.0	3.0	3.0	1.0						7930.4
7	6.0	3.0	6.0	1.0	PX	PY	M			4567.1
8	7.0				39810.0	10390.0	86200.0			0.0
9	8.0									0.0
10	9.0				PY/SD	PX/SD	M/J			0.0
11	10.0				1731.7	6635.0	1741.4			0.0
12	11.0									0.0
13	12.0									0.0
14	13.0									0.0
15	14.0									0.0
16	15.0									0.0
17	16.0									

BOLT LOADS - (8)

(8)	A	B	C	D	E	F	G	H	I	J
1	FAST NO	X	Y	DIA	SUMD	SUMDX	SUMDY	SUMDX2	SUMDY2	F
2	1.0	0.0	0.0	1.0	6.0	18.0	9.0	90.0	27.0	10883.8
3	2.0	3.0	0.0	1.0						10572.7
4	3.0	6.0	0.0	1.0	XBAR	YBAR	J			10777.5
5	4.0	0.0	3.0	1.0	3.0	1.5	49.5			13178.2
6	5.0	3.0	3.0	1.0						12922.5
7	6.0	6.0	3.0	1.0	PX	PY	M			13090.6
8	7.0				70470.0	1470.0	-38780.0			0.0
9	8.0									0.0
10	9.0				PY/SD	PX/SD	M/J			0.0
11	10.0				245.0	11745.0	-783.4			0.0
12	11.0									0.0
13	12.0									0.0
14	13.0									0.0
15	14.0									0.0
16	15.0									0.0
17	16.0									

ELEV 165 - JOINTS (CONT'D)

BOLT LOADS - ②

	A	B	C	D	E	F	G	H	I	J
	FAST NO	X	Y	DIA	SUMD	SUMDX	SUMDY	SUMDX2	SUMDY2	F
	1.0	0.0	0.0	1.0	4.0	6.0	6.0	18.0	18.0	5295.4
	2.0	0.0	3.0	1.0						3151.4
	3.0	3.0	0.0	1.0	XBAR	YBAR	J			5519.2
	4.0	3.0	3.0	1.0	1.5	1.5	18.0			3514.6
	5.0									0.0
	6.0				PX	PY	M			0.0
	7.0				6060.0	810.0	35860.0			0.0
	8.0									0.0
	9.0				PY/SD	PX/SD	M/J			0.0
1	10.0				202.5	1515.0	1992.2			0.0
2	11.0									0.0
3	12.0									0.0
4	13.0									0.0
5	14.0									0.0
6	15.0									0.0
7	16.0									

ARTIN MARIETTA
IICHOUD OPERATIONS

SHEET ____ OF 17-15

VC DATE 3/30 SUBJECT PFBTS.

WORK PACKAGE

ROVED ____ DATE ____

PROVED ____ DATE ____ REV ____ DATE ____

ELEV 169 - MEMBER LOADS

		1 Ma	2	1 Mb	2	1 S	2	P	
	A	B	C	D	E	F	G	H	I
1	654	-220135	-2182	201048	2583	-2507	-24	4444	-12
2	655	-47123	13581	-51391	-7464	-286	147	36376	-474
3	656	207861	27058	-129648	11238	2150	139	32387	384
4	657	-206874	12626	313546	-29997	-3212	263	-25650	84
5	658	281807	8349	-274764	-7271	3047	86	-7184	64
6	659	-391228	1423	465265	-3179	-4694	23	-11313	33
7	660	649939	-5774	-683820	6722	8104	-76	11577	53
8	661	-46160	1833	187091	-1812	-1178	18	25456	-26
9	662	36619	-6255	41834	6066	-64	-76	-20834	-24
10	663	-416199	15347	136740	24475	-2326	-85	-22494	232
11	664	-359492	-36375	526603	67290	-5470	-640	-68182	-272
12	665	128768	7154	-115094	0	2903	85	-95547	-643
13	666	-141364	25929	-72879	14576	-1181	-589	-81173	-711
14	667	598985	-27875	-325376	25988	19655	-1146	-197236	-714
15	668	74833	-30277	-155649	-68266	4904	1820	-217069	-1501
16	669	204397	54528	43095	-30276	2481	1266	-276557	-1505
17	670	-102382	0	150114	14013	-1606	-89	-206814	1591
18	671	262374	-35926	-223025	-60460	4258	807	-35497	27
19	672	-11499	-3685	-62353	8002	508	-83	9762	16
20	673	746874	0	919746	-35139	-1743	308	25466	1766
21	674	0	0	-171314	4548	1067	-28	-39810	0
22	675	233280	-14462	5257360	17120	-45554	-268	22049	98
23	676	-86233	46486	581154	-41688	-8114	1076	19453	-21
24	677	624002	-6148	0	0	7829	-77	-37306	0
25	678	-139122	13746	411957	-17749	-5054	286	2006	565
26	679	380045	-62282	325715	62458	1609	-1465	-70466	-562
27	680	-134888	27194	170075	-19681	-2675	411	-79793	-328
28	681	-222229	-60460	263091	-36481	-4257	807	-34392	-24
29	682	17127	-3148	-58843	-7694	536	76	-10558	-16
30	683	909678	-42952	812277	0	854	-377	28782	-1671
31	684	0	0	-168552	-5101	1050	32	-39779	0
32	685	6293170	24233	1346420	-13353	44944	311	23594	112
33	686	-63041	-46485	573232	41999	-7687	-1084	19674	20
34	687	615147	6291	0	0	7718	79	-37631	0
35	688	380568	61270	312079	-61785	1484	1445	-70260	552
36	689	-142401	-16423	414243	18847	-5105	-319	-5873	-559
37	690	155675	-16980	-132705	26115	2529	-378	-84021	317
38	691	124772	-5716	-112231	0	2821	-68	-95311	512
39	692	-144488	-27732	-70313	-18132	-1290	630	-81107	672
40	693	607816	25869	-330394	-27788	19959	1142	-199074	672
41	694	77405	30612	-161432	69593	5082	-1820	-218802	1516
42	695	207734	-58677	44899	30612	2490	-1333	-279628	1519
43	696	-94366	0	146338	-11821	-1533	75	-206475	-1652
44	697	379069	-30525	-341696	13743	4449	-273	-25465	-103
45	698	318216	-6830	-370971	6840	3774	-75	-7481	-70
46	699	-376685	-1080	453112	2824	-4547	-21	-10613	-31
47	5650	652723	5194	-685047	-6380	8129	70	12457	-49
48	5651	-44849	-1978	191619	1993	-1194	-20	25329	26
49	5652	44572	6093	35534	-6203	126	76	-20726	23
50	5653	-429364	-13256	152878	-22218	-2471	63	-23155	-233
51	5654	625122	66799	-417432	-36062	6436	635	-73548	299
52	5655	-245653	2064	295567	-1874	-3222	22	4007	31
53	5656	-49498	-13837	-56890	6913	-543	-143	37138	471
54	5657	203938	-26463	-125463	-11981	2098	-133	34126	-386
55	8001	-3485570	0	0	0	-221844	0	0	0
56	8002	-3485570	0	0	0	-221844	0	0	0
57	8013	-279615	41121	-3478010	-49621	34823	863	-8370	5826
58	8014	0	-35778	0	29279	0	-807	-6055	33
59	8015	0	35863	0	-28491	0	798	-6061	-30
60	8016	-297502	-41778	-3477760	47386	34739	-848	-8390	-5895

ARTIN MARIETTA
ICHOUD OPERATIONS

SHEET ____ OF 18-1

VC DATE 3/30 SUBJECT PFBIS

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PROVED DATE REV DATE

ELEV 214 & 147 - COLUMN ALLOW.

THIS SECTION INCLUDES A HAND CHECK ON THE COLUMN ALLOWABLES AT LEVELS 147 & 214. THE DECK MEMBERS ARE ATTACHED TO THE DECKING SUPPORT BEAMS, WHICH EFFECTIVELY REDUCE THEIR COLUMN LENGTH. THIS IS NOT REFLECTED IN THE STRESS PROGRAM, SINCE THE DECKING SUPPORT BEAMS ARE NOT INCLUDED IN THE MODEL. AS A RESULT, THE FOLLOWING MEMBERS SHOW STRESS RATIOS > 1 IN THE STRESS PROGRAM:

ELS 458
459
490
491
1058
1061
1088
1091.

ELEV 214 & 147 - COLUMN ALLOW

EL 214

MEMBER	PMAX	ORIG SIZE	EFFECTIVE L (IN)		M_{B}	
1058	-18240	63	? ±		7500	
1059	-9116				2530	
1060	-41070			*	2610	
1061	-27600				2470	
1067	▷17770				3320	
1076	-18330				4080	*
1088	-22440				1040	
1089	-11640				2910	
1090	-38080				1450	
1091	▷26140				740	

$2\frac{1}{2}$ $\frac{1}{4}$ $2\frac{1}{2}$

$A = 2.38$
$I_1 = 1.41$
$I_2 = 2.71$
$\bar{y} = .72$

5/8 x 4 1/8 PLATE

$y = .72 + .19 = .91$

$f_c = 41070 / 2.38 = 17260$

$M_1 = 41070 (.91) = 37370$ IN-LB.

$f_{b1c} = 37370 (.72) / 1.41 = 19080$

$M_2 = 4080.$ (BLANKETING)

$f_{b1T} = 37370 (1.78 / 1.41) = 47180$

$f_{b2} = \pm 4080 (1.25) / 2.71 = \pm 1880.$

i.e. $f_{c\,AV} = 17260$

$f_{t\,MAX} = 47180 - 17260 = 29920$

$f_{c\,MAX} = 17260 + 19080 + 1880 = 38220$

SYMMETRICAL COLUMN NO INDUCED MOMENT

REF AISC (FABRICATED) WITH K = 1, L = 55, $P_{ALL} = 35^K$, ASSUMES ╥

i.e. # 1060 & # 1090 FAIL ANYWAY

▷ ASSUME MAXIMUM ALMOST EQUALLY HIGH NEGATIVE LOADS

VC DATE 3/30 SUBJECT PPBTS

WORK PACKAGE ____

[APPR]OVED ____ DATE ____

[AP]PROVED ____ DATE ____ REV ____ DATE ____

ELEV 214 & 147 — COLUMN ALLOW.

NEXT HIGHEST , P = 27600 M_1 = 27600 (.91) = 25120.

M_B = 4080

$f_{c\,AV}$ = 11600.

$f_{b,c}$ = 12820.

$f_{b,t}$ = 31710

f_{b_2} = ± 1880

IE $f_{c\,AV}$ = 11600

$f_{t\,MAX}$ = 31710 − 11600 = 20110

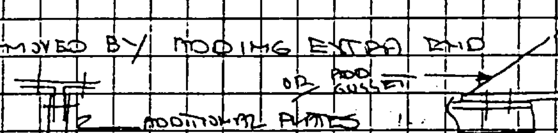
$f_{c\,MAX}$ = 11600 + 12820 + 1880 = 26300

AS COLUMN, NEGLECTING BENDING, R_c = 27600/35000 = .789.

THIS IS TERM 1 OF AISI EQ. 1.6-1A.

TERM 1 + TERM 2 > 1 FOR ABOVE f_b VALUES AND ANY BENDING ALLOWABLE ≤ 36 KSI.

THIS OFFSET MOMENT CAN BE REMOVED BY ADDING EXTRA END ATTACHMENTS IN VERT PLANE



HOWEVER, STADD-III WAS RUN WITH FIXED-FIXED ENDS, AND M_A VALUES ARE:

	M_A
1058	7145
1059	6943
~~1060~~	~~53180~~
1061	11,890
1067	460
1076	460
1088	11240
1089	7470
~~1090~~	~~29930~~
1091	9280.

M_A VALUES STILL PRESENT FROM STRUCTURAL DEFORMATION, MAXIMUM REDUCES TO 11,890

IE. TAKE P = 27600

M_1 = 11890

M_2 = 4080.

$f_{c\,AV}$ = 11600   IE $f_{c\,AV}$ = 11600

$f_{b\,c}$ = 6070 $f_{t\,MAX}$ = 3410

$f_{b\,t}$ = 15010 $f_{c\,MAX}$ = 19550

f_{b_2} = ± 1880

IE. 1) CHANGE # 1060 & # 1090.

2) ADD FIXING PLATES AT ENDS.

ARTIN MARIETTA
ICHOUD OPERATIONS

JC DATE 3/30 SUBJECT PFBTS SHEET ___ OF 19-4

WORK PACKAGE

ROVED ___ DATE ___

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- -ELEV. 147 -COLUMN ALLOW

MEMBER	Pmax	ORIG SIZE	EFFECTIVE L	MB	MA
457	22660	63	83"	900	0
458	-7660		103	1940	
459	-9670		72	990	
460	-15460		68	900	
466	-2670		77	3190*	
476	2970		77	2630	
489	22820*		83	650	
490	-7770		103	2120	
491	-8890		72	1160	
492	14840		68	880	

FOR: 457 USE P = 22820 AS FOR 2214.
460 MB = 880. MA = .91(22820) = 20770
489
492
fc = 22820/2.38 = 9590
fb,c = 22820(.72)/1.41 = 11650
fb,T = 22820(1.78)/1.41 = 28810
fb2 = ± 880(1.25)/2.71 = 400 psi

i.e. fc AV = 9590
fT MAX = 28810 - 9590 = 19220
fc MAX = 9590 + 11650 + 400 = 21640.

A151 K = 1 L = 83" = 7'. Pmax = 28k.
Rc = 22.8/28 = .81.
ON SAME BASIS AS NODAL 214, ADD FIXING PLATES.

FOR 458 USE P = 9670 MA = .91(9670) = 8800
459 MB = 3,190.
466 fc = 9670/2.38 = 4060
476 fb,c = ±4490
490 fb,T = 11110
491 fb2 = ±1470

fc AV = 4060
fc MAX = 4060 + 4490 + 1470 = 10020
fT MAX = 11110 - 4060 = 7050.

FORM MAF/MMA 35-016-04/74
NASA-MSFC-MAF

ORIGINAL PAGE IS
OF POOR QUALITY

ARTIN MARIETTA
ICHOUD OPERATIONS

JC	DATE 3/30	SUBJECT PFBTS
WORK PACKAGE		SHEET ___ OF 18-5
.OVED	DATE	
PROVED	DATE	REV ___ DATE ___

ELEV 14) – COLUMN ALLOW

GL 146 (CONT'D)

A 9 5 1, $L = 103 = 8.6$, $P_{ALL} = 33^K$

$R_L = 9.67/33 = .29$

$R_{b,c} + R_{b_2} = 4490 + 1470 = 5960$

FOR $R = 1$, $1 - .29 = .71$. $\frac{5960}{ALL} = .71$, $A_{LL} = 8390$

I.E. A BENDING ALLOWABLE AS LOW AS 8390 WOULD GIVE $R_{NET} = 1$

IE THESE MEMBERS O.K.

I.E. 1) ADD FIXING PLATES TO #457, #460, #489, #492

2) LEAVE REST AS IS.

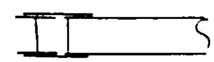
JOINTS – ELEV. 147

EL 147:

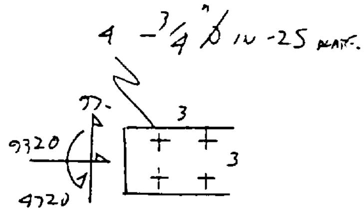
	(A)	(B)
MEMBERS	468	8021
	469	8022
	470	8023
	471	8024
	472	
	478	
	479	
	480	
	481	
	482	

THESE MEMBERS ARE CHANGED TO 6B16's DUE TO DESIGN REQUIREMENTS IMPOSED BY TANK STAY ROD END CONNECTIONS.

MAKE FLANGE END CONNECTIONS AS SHOWN



SET A, BLANKETING, $P_{MAX} = 8890$.
$S_{1MAX} = 345$
$S_{2MAX} = 97$
$M_{1MAX} = 30480$
$M_{2MAX} = 4720$

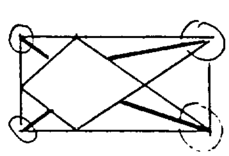


FLANGE END LOAD $= 8890/2 + 30480/6.25 = 9320$.

$P_{BOLT\,MAX} = 2760$ LB.

3/4" BOLT IN .25 PLATE, $P_{ALL} = 9720$. $R < .5$

SET 'B' LOADS ARE LESS. I.E. ABOVE CONNECTIONS O.K. AT 'OUTER' ENDS, I.E.



AT 'INNER' ENDS, CONNECTIONS ARE FLANGE-TO-FLANGE WELDS TO GIVE MOMENT & END LOAD CAPABILITY WHILE ALLOWING ATTACHMENT OF BRACKET BASEPLATE (SEE SECTION ON TANK STAY RODS & BRACKETS).

MARTIN MARIETTA
MICHOUD OPERATIONS

VC DATE 3/30 SUBJECT PFBTS SHEET ____ OF 19-2

WORK PACKAGE

APPROVED ______ DATE ______

APPROVED ______ DATE ______ REV ______ DATE ______

JOINTS – ELEV 147

BOLT LOADS

A	B	C	D	E	F	G	H	I	J
FAST NO	X	Y	DIA	SUMD	SUMDX	SUMDY	SUMDX2	SUMDY2	F
1	0	0	1	4	6	6	18	18	2748
2	0	3	1						1972
3	3	0	1	XBAR	YBAR	J			2755
4	3	3	1	1.5	1.5	18			1981
5									0
6				PX	PY	M			0
7				9320	97	4720			0
8									0
9				PY/SD	PX/SD	M/J			0
10				24.25	2330	262.222222			0
11									0
12									0
13									0
14									0
15									0
16									0

ARTIN MARIETTA
ICHOUD OPERATIONS

JC DATE 3/30 SUBJECT PFBTS SHEET ____ OF 19-3

WORK PACKAGE

ROVED ____ DATE ____

ROVED ____ DATE ____ REV ____ DATE ____

ELEV 147 - MEMBER LOADS

	A	B	C	D	E	F	G	H	I
1	ELEMENT	MA1	MA2	MB1	MB2	S1	S2	P	T
2	453	-266814	-26908	270606	11573	-3199	-229	-9348	21
3	454	-15331	-51043	-26499	-44758	113	668	37620	121
4	455	92270	-41367	-43285	-51020	863	-586	-48755	-122
5	456	-599805	25422	1070720	-19744	-9622	251	150288	2028
6	457	1302	924	-2293	-815	20	9	23000	12
7	458	0	1948	0	-1593	0	19	-7798	13
8	459	0	309	0	-956	0	6	-8981	-20
9	460	-4468	-977	5700	-670	-45	-7	16330	-17
10	461	-309235	-36503	735386	-27615	-6209	338	311122	-996
11	462	1800320	-16314	-2630	38406	21722	-648	3052	-330
12	463	2065840	21896	1788980	-17820	1275	174	10614	-1009
13	464	-591	-23469	2083820	26321	-13277	-317	-2214	1673
14	465	1071060	-32734	-1322950	-46915	20591	-696	152256	-219
15	466	0	-3191	0	2404	0	-41	-2760	-7
16	467	11697	0	37705	2277	-319	-20	11855	-24
17	468	30218	-249	0	514	187	-5	8892	-21
18	469	27753	-2032	30477	598	-35	-33	8266	-55
19	470	0	4598	27844	-3225	-345	95	8177	232
20	471	0	-2703	16923	2176	-146	-42	4170	-27
21	472	16860	-693	0	2351	215	-38	2595	-164
22	474	735121	-10846	-1229250	11954	16808	-193	312668	-499
23	475	-1321060	-46916	1040610	31966	-20478	-692	151426	231
24	476	0	2629	0	-1217	0	26	2994	7
25	477	36242	2813	10981	0	315	25	11679	24
26	478	30401	290	0	-622	189	6	8728	21
27	479	0	-4716	27753	3242	-344	-97	8007	-233
28	480	27661	2031	30294	-584	-34	32	8428	55
29	481	16860	701	0	-2354	215	39	2862	165
30	482	0	2676	16919	-2148	-146	42	4427	27
31	484	-1230110	11900	742816	-11555	-16865	200	312642	503
32	485	1805240	14674	-2572	-35376	21781	599	2755	323
33	486	2065780	-21712	1790220	16584	1262	-168	9951	1005
34	487	-587	24899	2086050	-26503	-13291	327	-2312	-1676
35	488	1040320	-15050	-700408	10993	10082	-130	149315	-2054
36	489	1350	-675	-2411	399	21	-6	23123	-12
37	490	0	-2122	0	1684	0	-21	-7874	-13
38	491	0	-401	0	1123	0	-7	-8239	20
39	492	-4507	-924	5751	803	-46	-8	15827	17
40	493	743090	-30815	-286664	34835	6153	-405	311084	996
41	494	-267477	27399	281519	-16432	-3268	261	-9339	-19
42	495	-12636	51132	-27825	46882	120	-683	-39557	-9
43	496	89738	-42815	-41300	51117	831	-598	-48200	26
44	8021	339	-1392	0	976	2	-13	-1687	-40
45	8022	0	2016	-239	-2126	2	40	-1790	15
46	8023	341	1455	0	-1085	2	14	-1690	40
47	8024	0	-1861	-239	2054	2	-37	-1788	-15

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JOINTS – ELEV 147

EL 147.

UNALTERED MEMBERS =

457	466	489
458	476	490
459		491
460		492.

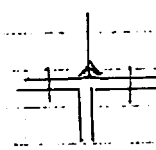
$P_{MAX} = 22810$

$S_{1\,MAX} = 46$

$S_{2\,MAX} = 41$

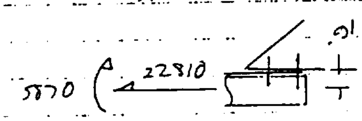
$M_{1\,MAX} = 5870$

$M_{2\,MAX} = 3190$

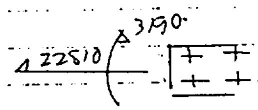


SAY 4 – 3/4" IN 3/8" JOINT PLATE

$P_{SHEAR\ NUT\ MAX} = 5975$



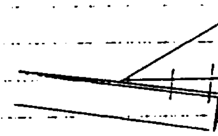
TAKE $M_1 = 5870 + .91(22810) = 26{,}630$
AT JOINT LINE

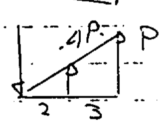


$26{,}630 = 2(2(.4P) + 5P)$

$= 11.6P$

$P = 2300$





$R_S = 5975/9720 = .61$ $R_{NET} = (.61^2 + .13^2)^{1/2}$

$R_T = 2300/17600 = .13$ $= .62$

MEMBERS

8021
8022
8023
8024

$P_{MAX} = 1750$

$S = 36$

$M_{MAX} = 1780$

SAME END ATTACH O.K.

ARTIN MARIETTA
CHOUD OPERATIONS

VC DATE 3/30 SUBJECT PFBTS SHEET ____ OF 10-5

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JOINTS - ELEV 147

EL 147

MEMBERS

468	478
469	479
470	480
471	481
472	482

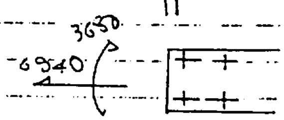
$P_{MAX} = 6940.$ SAY 4 - 3/4 in. 3/8 JOINT PLATE

$S_{1MAX} = 306$

$S_{2MAX} = 76.$

$M_{1MAX} = 10,480$

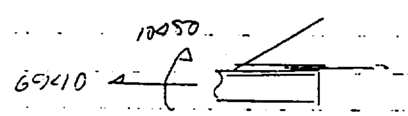
$M_{2MAX} = 3680.$



$P_{SHEAR\ BOLT\ MAX} = 2070$

TAKE M_1 AT JOINT LINE

$= 10480 + 6940(.91) = 16,800$



$P_{T\ ON\ BOLT\ MAX} = 16800/11.6 = 1450$

$R_S = 2070/9720 = .21$ $R_{HE} \doteq .021$

$R_T = 1450/17670 = .08$

ARTIN MARIETTA
ICHOUD OPERATIONS

JC DATE 3/30 SUBJECT PFBTS SHEET ____ OF 19-6

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JOINTS - ELEV 147

BOLT LOADS

	A	B	C	D	E	F	G	H	I	J
1	FAST NO	X	Y	DIA	SUMD	SUMDX	SUMDY	SUMDX2	SUMDY2	F
2	1.0	0.0	0.0	1.0	4.0	6.0	6.0	18.0	18.0	2061.8
3	2.0	3.0	0.0	1.0						2067.5
4	3.0	0.0	3.0	1.0	XBAR	YBAR	J			1457.0
5	4.0	3.0	3.0	1.0	1.5	1.5	18.0			1465.0
6	5.0									0.0
7	6.0				PX	PY	M			0.0
8	7.0				6940.0	76.0	3680.0			0.0
9	8.0									0.0
10	9.0				PY/SD	PX/SD	M/J			0.0
11	10.0				19.0	1735.0	204.4			0.0
12	11.0									0.0
13	12.0									0.0
14	13.0									0.0
15	14.0									0.0
16	15.0									0.0
17	16.0									

VC DATE 3/30 SUBJECT PFBTS.

WORK PACKAGE

'ROVED DATE

'ROVED DATE REV DATE

JOINTS - ELEV 19

BOLT LOADS

	A	B	C	D	E	F	G	H	I	J
1	FAST NO	X	Y	DIA	SUMD	SUMDX	SUMDY	SUMDX2	SUMDY2	F
2	1.0	0.0	0.0	1.0	4.0	6.0	6.0	18.0	18.0	5442.7
3	2.0	3.0	0.0	1.0						5443.7
4	3.0	0.0	3.0	1.0	XBAR	YBAR	J			5973.8
5	4.0	3.0	3.0	1.0	1.5	1.5	18.0			5974.7
6	5.0									0.0
7	6.0				PX	PY	M			0.0
8	7.0				-22810.0	41.0	3190.0			0.0
9	8.0									0.0
10	9.0				PY/SD	PX/SD	M/J			0.0
11	10.0				10.3	-5702.5	177.2			0.0
12	11.0									0.0
13	12.0									0.0
14	13.0									0.0
15	14.0									0.0
16	15.0									0.0
17	16.0									

MARTIN MARIETTA
MICHOUD OPERATIONS

VC DATE 3/30 SUBJECT PFBTS SHEET ____ OF 19-8

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ELEV 147 - MEMBER LOADS

	A	B	C	D	E	F	G	H	I
1					EL 146				
2	ELEMENT	MA1	MA2	MB1	MB2	S1	S2	P	T
3	453	-266550	-27196	270095	11481	-3194	-230	-9223	21
4	454	-15370	-51049	-26352	-44269	112	665	38203	121
5	455	91969	-41476	-43154	-51026	861	-588	-48116	-122
6	456	-592070	25139	1058480	-19549	-9495	246	150622	1996
7	457	1261	897	-2246	-800	19	9	22699	12
8	458	0	1940	0	-1577	0	19	-7684	13
9	459	0	358	0	-989	0	6	-9642	-20
10	460	-4506	-972	5832	-678	-46	-7	15392	-17
11	461	-304513	-36081	728942	-28651	-6141	348	311916	-982
12	462	1773090	-17555	-2597	38053	21394	-647	3056	-334
13	463	2030680	24115	1754920	-18762	1272	188	11124	-999
14	464	-525	-24730	2055480	27233	-13095	-331	-2152	1661
15	465	1058820	-32838	-1312460	-47018	20392	-696	152504	-215
16	466	0	-3194	0	2412	0	-41	-2653	-7
17	467	11806	0	38435	2278	-328	-20	12926	-24
18	468	0	-224	0	434	0	-4	6942	-3
19	469	24918	-1678	35596	-451	-134	-27	6370	25
20	470	0	3490	-24963	-2486	-306	72	6534	-24
21	471	0	-1692	10552	1197	-97	-27	3339	21
22	472	10479	-2767	0	-3676	123	-76	1827	-45
23	474	728651	-11559	-1218920	13599	16653	-219	313559	-509
24	475	-1310840	-47020	1034050	31858	-20330	-692	151685	224
25	476	0	2632	0	-1223	0	26	2879	7
26	477	36973	2813	11107	0	323	25	12720	24
27	478	35617	256	0	-518	221	5	6825	25
28	479	0	-3577	6967	2496	-85	-72	6487	-26
29	480	6920	1689	0	-443	87	27	6487	-48
30	481	10479	2773	0	-3662	123	76	2019	44
31	482	0	1682	10551	-1181	-97	26	3522	-20
32	484	-1219440	13644	730855	-12216	-16659	224	313576	519
33	485	1786890	15996	-2535	-35043	21559	599	2746	327
34	486	2014180	-23952	1765310	17517	1147	-182	10454	995
35	487	-510	26050	2041070	-27391	-13003	340	-2241	-1663
36	488	1033750	-14846	-695785	10704	10009	-125	149684	-2020
37	489	1310	-647	-2361	384	20	-6	22809	-12
38	490	0	-2115	0	1667	0	-21	-7753	-13
39	491	0	-453	0	1161	0	-8	-8960	20
40	492	-4530	-888	5867	796	-46	-7	14858	18
41	493	731153	-31467	-278300	34483	6027	-407	311922	978
42	494	-267243	26468	281253	-15726	-3265	251	-9234	-19
43	495	-12575	51166	-27923	46985	121	-683	-39042	-9
44	496	89478	-42628	-41185	51151	828	-597	-47556	26
45	8021	0	-921	0	635	0	-9	-1642	-61
46	8022	0	1782	0	-1954	0	36	-1751	19
47	8023	0	962	0	-704	0	9	-1644	55
48	8024	0	-1722	0	1915	0	-35	-1750	-19

ARTIN MARIETTA
ICHOUD OPERATIONS

SHEET _____ OF 20-1

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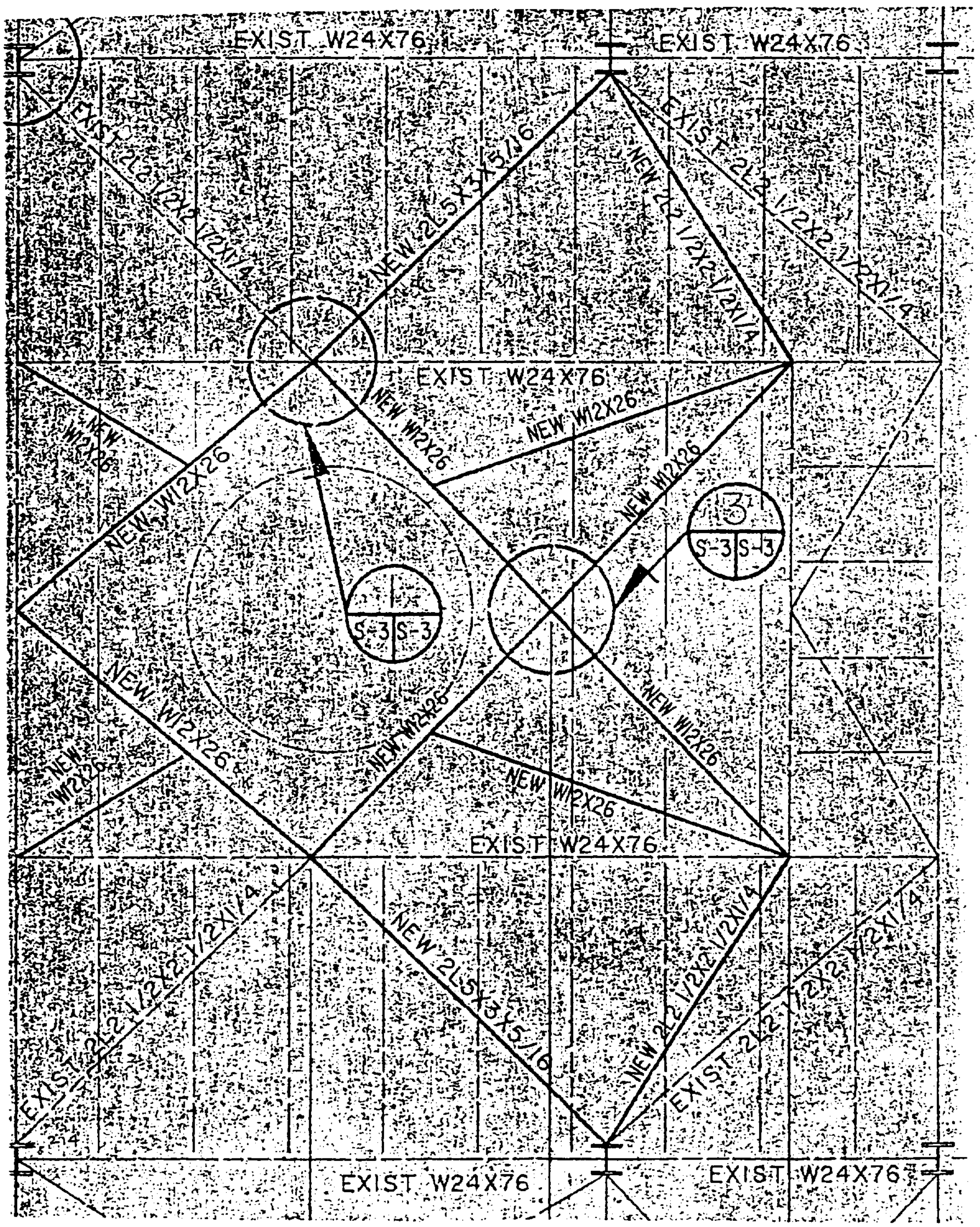
ELEV 214 - JOINTS.



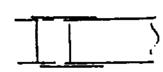
ELEV 216 - JOINTS

	(A)	(B)
MEMBERS	1069	8025
	1070	8026
	1071	8027
	1072	8028
	1073	
	1078	
	1079	
	1080	
	1081	
	1082	

THESE MEMBERS ARE CHANGED TO 12WF. DUE TO DESIGN REQUIREMENTS IMPOSED BY TANK STAY ROD END CONNECTIONS.

MAKE FLANGE END CONNECTIONS AS SHOWN

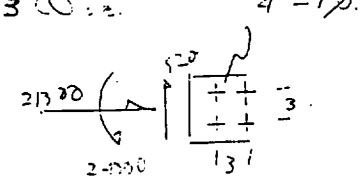
SET A LOADINGS;
$P_{max} = 26820$
$S_{1max} = 997$
$S_{2max} = 521$
$M_{1max} = 94730$
$M_{2max} = 24390$



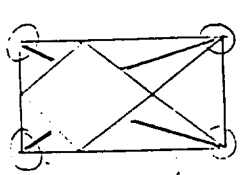
FLANGE END LOAD = 26820/2 + 94730/12 = 21.3 K.

$P_{BOLT\ MAX} = 7670$

1" BOLTS IN 3/8 PLATE $P_{ALL} = 11,260$
R < 0.5.



SET B LOADS ARE LESS. ABOVE CONNECTIONS O.K. AT 'OUTER' ENDS, I.E.



AT 'INNER' ENDS, CONNECTIONS ARE FLANGE-TO-FLANGE WELDS TO GIVE FULL MOMENT & END LOAD CAPACITY WHILE ALLOWING ATTACHMENT OF BRACKET BASE-PLATE (SEE SECTION ON TANK STAY RODS & BRACKETS).

ARTIN MARIETTA
MICHOUD OPERATIONS

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ELEV 214 - JOINTS (CONT'D)

BOLT LOADS

	A	B	C	D	E	F	G	H	I	J
1	FAST NO	X	Y	DIA	SUMD	SUMDX	SUMDY	SUMDX2	SUMDY2	F
2	1	0	0	1	4	6	6	18	18	7599
3	2	0	3	1						3803
4	3	3	0	1	XBAR	YBAR	J			7669
5	4	3	3	1	1.5	1.5	18			3939
6	5									0
7	6				PX	PY	M			0
8	7				21300	520	24390			0
9	8									0
10	9				PY/SD	PX/SD	M/J			0
11	10				130	5325	1355			0
12	11									0
13	12									0
14	13									0
15	14									0
16	15									0
17	16									0

ARTIN MARIETTA
ICHOUD OPERATIONS

SHEET ______ OF 204

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ELEV 214 – MEMBER LOADS

	Element	M_{A1}	M_{A2}	M_{B1}	M_{B2}	S_1	S_2	P	T
	A	B	C	D	E	F	G	H	I
1	1050	-49342	10784	51313	-6388	-599	102	1554	12
2	1051	14914	-6394	-56940	11315	374	-92	-8920	-58
3	1052	-14182	10807	-16413	-10728	-159	110	-13805	-5
4	1053	-49564	-21249	18065	-6989	-190	-73	22338	-22
5	1054	-764918	29974	91912	-11562	-5100	214	1407	117
6	1055	121849	-52472	-465944	32461	3787	-562	44300	-71
7	1056	38499	-54156	99026	-52465	-426	-650	-10849	-121
8	1057	-291962	-18104	696727	-30030	-6496	-259	-9634	1345
9	1058	-2633	1585	4291	-1370	-30	13	-18067	11
10	1059	-6625	2705	8355	-2585	-83	30	-9152	13
11	1060	-57088	-2847	68434	1295	-590	-19	-42287	-9
12	1061	-4065	-2584	3878	1493	-38	-20	-28450	-11
3	1062	-288372	-44239	1102820	28813	-9183	-370	31493	-1152
4	1063	2062600	54906	-92690	-90599	27427	1940	11691	614
15	1064	2401210	5616	2064880	19430	1740	-68	40351	81
16	1065	-1462	-16980	2535800	35717	-17026	-354	17910	-321
17	1066	583575	42124	-427661	55247	8122	635	-52549	-107
18	1067	-87	-3545	966	-1878	-7	-36	17729	-5
19	1068	-39379	0	-13280	3490	-219	-28	19132	-21
20	1069	94732	-6526	65978	10225	279	-96	-23802	-77
21	1070	42578	19981	91517	-21170	-849	472	-22819	77
22	1071	91476	-17502	93817	12521	-282	-344	-26023	95
23	1072	83359	-12922	88911	17741	-619	-378	-17801	-128
24	1073	-47451	5956	83414	-5020	-997	92	-19639	-62
25	1074	1102480	11628	-1141580	-17257	17773	232	40928	93
26	1075	-400087	55260	534007	38758	-7423	664	-47303	128
27	1076	165	-4499	1008	2952	-8	-51	-17760	6
28	1077	-13387	-3993	-43339	0	247	-32	22774	22
29	1078	93841	6522	70532	-10779	254	99	-26818	79
30	1079	-23646	-24391	82263	22470	-962	-521	-20706	-84
31	1080	82223	18550	94708	-13096	-396	363	-23020	-103
32	1081	46401	-5086	81931	5494	-861	-94	19466	62
33	1082	81743	12428	71247	-16180	670	353	14576	126
34	1083	-1146450	-18131	1080880	24094	-17739	-339	41746	-111
35	1084	2070640	-46150	-104348	89968	27663	-1815	13767	-649
36	1085	2470010	9673	2072900	-24989	1949	121	44972	-124
37	1086	-1441	23648	2501850	-25066	-16799	327	17853	385
38	1087	632774	-34532	-416246	-30014	6870	-396	9044	-1279
39	1088	-2556	-1107	4276	1136	-30	-10	-22310	-11
40	1089	-6772	-2173	8516	2415	-86	-26	-11887	-13
41	1090	31650	1103	-26169	-1491	271	10	-39101	4
42	1091	-4141	888	4019	-685	-38	7	-25776	11
43	1092	1080890	-46444	-485097	31689	9887	-516	32331	1158
4	1093	-780014	-18127	564290	22623	-8002	-235	-2644	-85
5	1094	103407	-51066	-499546	-38016	3993	575	-46183	80
6	1095	115506	36743	93689	-51078	765	589	-10256	115
47	1096	-53019	-3520	30503	2145	-435	-30	11738	14

RM MAF/MMA 35-016-04/74
ISA-MSFC-MAF

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ELEV 214 - JOINTS

MEMBERS 1058 EXISTING JOINTS:

1059

1061

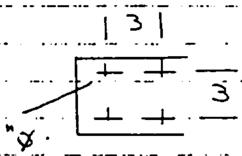
1067

1072

1088

1089

1091



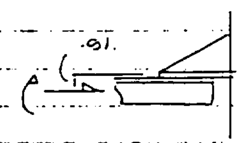
BUILDING: $P = 27600$

$S_1 = 80$

$S_2 = 45$

$M_1 = 7510$

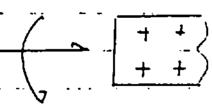
$M_2 = 4080$



3/4" FASTENERS BRG IN .25 ANGLE. $P_{ALL} = 9.1^k$

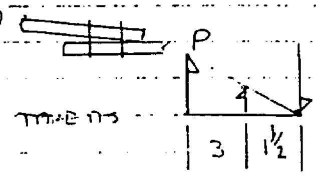
S_1, S_2 SMALL; NEGLECT.

$P_{BOLT\ MAX\ SHEAR} = 7250$ (1) $R_S = 7.25/9.1 = .8$ ✓



$M_{JOINT} = 27600(.91) - 7510$

$= 17600$



$17600 = 2(4.5P + 1.5P)$ $P = 1470$ lb.

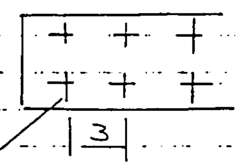
$P_{T\ ALL\ (BOLT)} = 17,700$. $R = .08$. $R_{NET} \doteq .08$ ✓

EXISTING JOINTS OK FOR ABOVE MEMBERS.

JOINT PLATES OK WITH ADDITION OF PROPOSED GUSSETS.

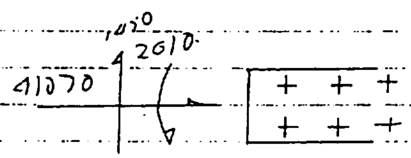
ELEV 214 - JOINTS (CONT'D)

ALTERED MEMBERS # 1060 MAKE
1090



6 — 3/4 ϕ

$P = 41070$
$S_1 = 1450$
$S_2 = 490$
$M_1 = 54530$
$M_2 = 2610$



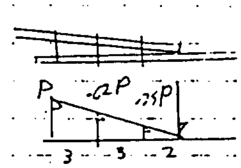
$P_{BOLT_{MAX\ SHEAR}} = 6940$ (2)

P_{ALL} in 7/8" =
$R_s = 6940/9720 = .71$

FOR 2L 5x3x5/16, CG. OFFSET FROM 3/8 JOINT PLATE ℄ = 1.68 + .19
= 1.87.

$41070(1.87) = 76800$
DESIGN TO THIS FOR M_1

$76800 = 2(8P + 5(.62P) + 2(.25P)) = 23.2P$
$P = 3310$
$P_{T\ ALL_{BOLT}} = 17670$

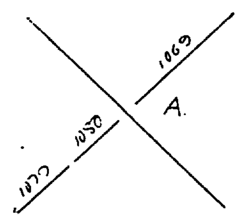


$R_T = 33.0/17.70 = .19$

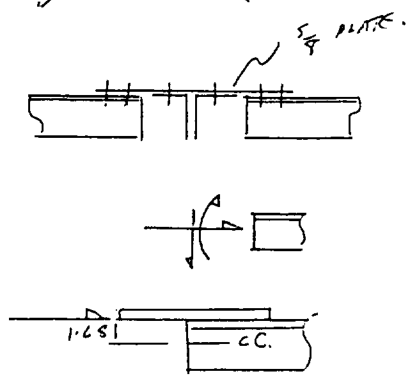
$R_{MS} = (.71^2 + .19^2)^{1/2} = .73$

ELEV 214 - JOINTS (CONT'D)

\# 1079 JOINT A.
1050
1069.

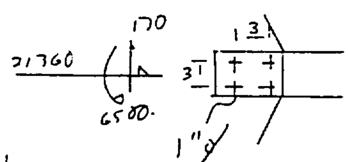


AT A, $P = -21{,}360$
$S_1 = 220$
$S_2 = 170$
$M_1 = 26020$
$M_2 = 6500$

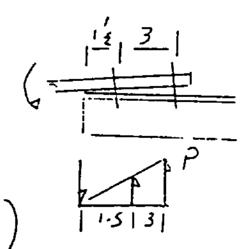


$21360(1.68) = 35{,}880.$

$P_{BOLT\,max\,(shear)} = 5910.$ ③
3/4" BOLTS $R = 5910/9720 = .61$



ALLOW PRYING BM
$= 35880 - 26020 = 9860$



P_{BOLT} TENSION FROM
$9860 = 2(4.5P + 1.5(.33P))$
$= 10P. \quad P = 990$
$R_T = 990/17670 = .06.$ NET BOLT $R = .61$

FOR 12" EFFECTIVE JOINT PLATE WIDTH THRU BOLT GROUP,
$f_c = 21360/.625(12) = 2850.$
$f_{b_1} = 9860 \times 6/12(.625)^2 = 12620.$
$f_{b_2} = 6500 \times 6/.625(12)^2 = 430.$
$f_{c\,max} = 15{,}900$ psi. ON BOLT PLATE.

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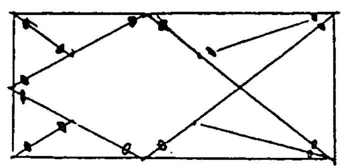
ELEV 214. - JOINTS (CONT'D)

JOINTS

*1069	B
*1070	A
1072	B
1073	A
1078	B
1079	A
1081	A
1082	B.
~~1085~~	~~1088 A + B.~~



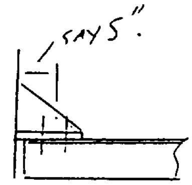
P = 24620

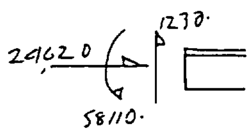
S_1 = 1230

S_2 = 740

M_1 = 58110

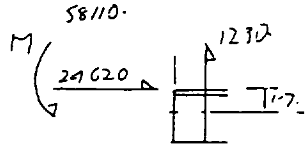
M_2 = 32,320



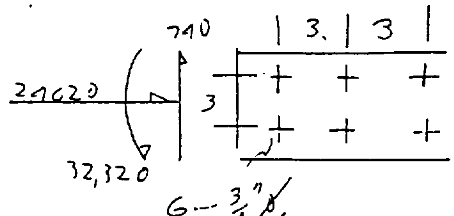


$M = 58110 + 24620(1.7) - 1230(5)$

$= 93820.$



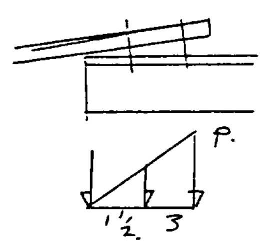
SHEAR ON BOLTS.



$P_{BOLT\ MAX\ SHEAR} = 5500$ (2)

$R_s = 5500 / 9720 = .57.$

PRYING FROM BENDING.



P FROM 93820 ÷ 23.2 P, AS BEFORE.

P = 4050

$R_{TENSION} = 4050 / 17670 = .23$

$R_{INT} = (.57^2 + .23^2)^{1/2} = .61$

#8025 - 8028. P_{MAX} = 20720 $P_{S\ MAX}$ = 5480 (5) (4 BOLTS)

S = 68 3/4" ϕ, $R_s = 5480 / 9720$

M = 3520.

= .56

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ELEV 214 – MEMBER LOADS

		1 MA	2	1 MB	2	1 S	2	P	T
	A	B	C	D	E	F	G	H	I
1	1050	-49149	10527	51100	-6119	-597	99	1545	12
2	1051	14871	-6124	-56800	10662	372	-87	-8856	-57
3	1052	-14354	10802	17372	-10685	-165	110	-13622	-5
4	1053	-49093	-20891	17866	-7410	-188	73	22208	-22
5	1054	-760730	29500	91439	-11142	-5072	213	1433	117
6	1055	122432	-52133	-464394	31550	3796	-554	42955	-71
7	1056	37473	-53255	99290	-52127	-433	-641	-11937	-121
8	1057	-290411	-18522	691375	25889	-6454	-264	-9561	1348
9	1058	-2635	1499	4297	-1237	-30	12	-18237	11
10	1059	-5884	2532	6954	2321	-70	27	-9116	16
11	1060	-50021	2607	54529	-1227	-492	18	-41070	-36
12	1061	-3109	-2474	2028	1337	-25	-18	-27597	-5
13	1062	-287039	-42352	1093240	30643	-9111	-353	30832	-1160
14	1063	2041750	48548	-93172	-93613	27140	1895	11734	-411
15	1064	2447880	13613	2106040	23761	1749	123	38151	-344
16	1065	-1188	-18194	2510420	33778	-16853	-349	17500	680
17	1066	580396	41229	-414488	54276	7991	654	-52425	-110
18	1067	145	-3322	-463	-1964	4	-34	17771	2
19	1068	13623	0	35416	3269	-198	-26	17766	46
20	1069	26016	-3207	-12474	4876	219	-46	-21355	-17
21	1070	-15113	11313	21868	-10385	-356	237	-20582	209
22	1071	21800	-8346	18707	6324	58	-173	-23526	-216
23	1072	86149	-28625	78615	32315	-677	-740	-18292	-894
24	1073	-58106	25201	86169	-25110	-1224	424	-19318	548
25	1074	1093580	23094	-1135240	-29144	17610	420	40377	-460
26	1075	-381949	54289	505191	36770	-6761	653	-47518	137
27	1076	247	-4082	-459	2660	4	-45	-18327	-2
28	1077	35288	-3675	10094	0	226	-28	21356	-42
29	1078	18173	3247	-8578	-4918	149	46	-24617	27
30	1079	-43831	-11586	11921	10200	-558	-238	-17864	66
31	1080	11906	8141	25780	-6504	-214	169	-20787	-180
32	1081	56873	-22973	50278	23610	605	-405	19342	1037
33	1082	50190	25894	-56040	-29364	1227	671	14862	979
34	1083	-1164580	-31373	1090320	30839	-17888	-500	40385	473
35	1084	2042900	-46174	-108599	96109	27283	-1897	14117	375
36	1085	2512100	13460	2107260	-35602	1847	201	42524	-653
37	1086	-1315	14736	2548210	24159	-17097	-260	17662	910
38	1087	602737	-31070	-405743	-30472	6836	415	8612	-1344
39	1088	-2637	-1040	4439	1026	-32	-9	-22444	-11
40	1089	-6389	-2141	7508	-2408	-80	-26	-11635	-17
41	1090	38800	495	-30334	-1447	329	9	-38080	-4
42	1091	-5167	736	5713	-446	-52	6	26144	16
43	1092	1091160	47333	-481368	29684	9928	487	31085	1188
44	1093	-784107	-17747	563808	22871	-8023	-235	-2504	-82
45	1094	101972	-51336	-496015	-37940	3960	573	-46838	80
46	1095	118792	35894	92445	-51347	803	586	-10936	115
47	1096	-52153	-3647	30217	2196	-429	-30	11396	14
48	1097	-206	-965	-7695	1570	60	-20	978	-4
49	1098	25951	1110	-50750	-699	476	14	-7234	-18
50	1099	31087	-70	-40089	1337	279	-6	6015	-22
51	1500	36692	1142	39311	556	-351	9	-14044	4
52	1501	-753	1171	-6813	-1599	35	15	-1327	-2
53	1502	-87380	18881	37790	-9063	-688	158	26359	61
54	1503	38316	-8034	-49685	3103	480	-60	27227	-39
55	1504	-1182	3505	1491	-2994	-16	31	4259	2
56	1505	-7027	137	5860	-244	-52	2	1766	4
57	1506	-267	-219	-3955	163	27	-3	-1084	-5
58	1507	-43430	855	21253	856	-450	12	-3257	9
59	1508	21476	849	-9425	-191	206	7	-2172	5
60	8025	0	-2039	0	3378	0	-25	-20266	-75
61	8026	0	3371	0	-3520	0	68	-20469	13
62	8027	0	-2552	0	3454	0	-61	-20288	-2
63	8028	0	2059	0	-3258	0	26	-20723	19
64	8029	-40063	-6484	25779	2917	-516	-74	-6468	12

RM MA
SA-M

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ELEV 214 - JOINTS (CONT'D)

BOLT LOADS - 1

	A	B	C	D	E	F	G	H	I	J
	FAST NO	X	Y	DIA	SUMD	SUMDX	SUMDY	SUMDX2	SUMDY2	F
	1.0	0.0	0.0	1.0	4.0	6.0	6.0	18.0	18.0	7247.5
	2.0	3.0	0.0	1.0						7248.5
	3.0				XBAR	YBAR	J			0.0
	4.0	0.0	3.0	1.0	1.5	1.5	18.0			6568.2
	5.0	3.0	3.0	1.0						6569.4
	6.0				PX	PY	M			0.0
	7.0				27600.0	45.0	4080.0			0.0
	8.0									0.0
0	9.0				PY/SD	PX/SD	M/J			0.0
	10.0				11.3	6900.0	226.7			0.0
	11.0									0.0
3	12.0									0.0
4	13.0									0.0
5	14.0									0.0
6	15.0									0.0
7	16.0									

BOLT LOADS - 2

A	B	C	D	E	F	G	H	I	J
FAST NO	X	Y	DIA	SUMD	SUMDX	SUMDY	SUMDX2	SUMDY2	F
1.0	0.0	0.0	1.0	6.0	18.0	9.0	90.0	27.0	6924.6
2.0	3.0	0.0	1.0						6928.3
3.0	6.0	0.0	1.0	XBAR	YBAR	J			6935.6
4.0	0.0	3.0	1.0	3.0	1.5	49.5			6766.4
5.0	3.0	3.0	1.0						6770.2
6.0	6.0	3.0	1.0	PX	PY	M			6777.7
7.0				41070.0	1450.0	2610.0			0.0
8.0									0.0
9.0				PY/SD	PX/SD	M/J			0.0
10.0				241.7	6845.0	52.7			0.0
11.0									0.0
12.0									0.0
13.0									0.0
14.0									0.0
15.0									0.0
16.0									

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ELEV 214 - JOINTS (CONT'D)

BOLT LOADS - (3)

3	A	B	C	D	E	F	G	H	I	J
1	FAST NO	X	Y	DIA	SUMD	SUMDX	SUMDY	SUMDX2	SUMDY2	F
2	1.0	0.0	0.0	1.0	4.0	6.0	6.0	18.0	18.0	5902.8
3	2.0	3.0	0.0	1.0						5910.6
4	3.0	0.0	3.0	1.0	XBAR	YBAR	J			4824.2
5	4.0	3.0	3.0	1.0	1.5	1.5	18.0			4833.8
6	5.0									0.0
7	6.0				PX	PY	M			0.0
8	7.0				21360.0	170.0	6500.0			0.0
9	8.0									0.0
10	9.0				PY/SD	PX/SD	M/J			0.0
1	10.0				42.5	5340.0	361.1			0.0
2	11.0									0.0
13	12.0									0.0
14	13.0									0.0
15	14.0									0.0
16	15.0									0.0
17	16.0									

BOLT LOADS - (4)

4	A	B	C	D	E	F	G	H	I	J
1	FAST NO	X	Y	DIA	SUMD	SUMDX	SUMDY	SUMDX2	SUMDY2	F
2	1.0	0.0	0.0	1.0	6.0	18.0	9.0	90.0	27.0	5404.0
3	2.0	3.0	0.0	1.0						5084.2
4	3.0	6.0	0.0	1.0	XBAR	YBAR	J			5492.7
5	4.0	0.0	3.0	1.0	3.0	1.5	49.5			3623.2
6	5.0	3.0	3.0	1.0						3126.4
7	6.0	6.0	3.0	1.0	PX	PY	M			3754.2
8	7.0				24620.0	740.0	32320.0			0.0
9	8.0									0.0
10	9.0				PY/SD	PX/SD	M/J			0.0
11	10.0				123.3	4103.3	652.9			0.0
12	11.0									0.0
13	12.0									0.0
14	13.0									0.0
15	14.0									0.0
16	15.0									0.0
17	16.0									0.0

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ELEV 214 - JOINTS (CONT'D)

BOLT LOADS - 5

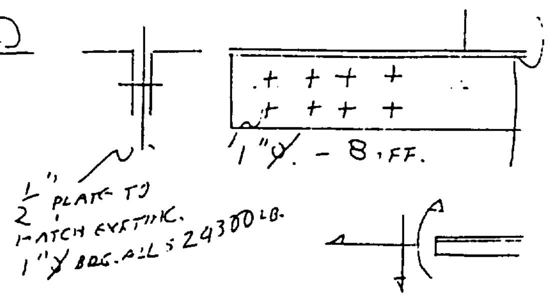
5	A	B	C	D	E	F	G	H	I	J
1	FAST NO	X	Y	DIA	SUMD	SUMDX	SUMDY	SUMDX2	SUMDY2	F
2	1.0	0.0	0.0	1.0	4.0	6.0	6.0	18.0	18.0	5480.3
3	2.0	3.0	0.0	1.0						5482.1
4	3.0	0.0	3.0	1.0	XBAR	YBAR	J			4894.5
5	4.0	3.0	3.0	1.0	1.5	1.5	18.0			4896.5
6	5.0									0.0
	6.0				PX	PY	M			0.0
	7.0				20720.0	68.0	3520.0			0.0
9	8.0									0.0
10	9.0				PY/SD	PX/SD	M/J			0.0
11	10.0				17.0	5180.0	195.6			0.0
12	11.0									0.0
13	12.0									0.0
14	13.0									0.0
15	14.0									0.0
16	15.0									0.0
17	16.0									

TRUSS 115–125 – JOINTS

ELEMENT TYPES USED ARE:

52	54	55	57	59	60	53
6 × 8 × 7/16	7 × 6 × 3/4	4 × 6 × 3/8	3½ × 5 × 3/8	3 × 5 × 5/16	3 × 4 × 1/4	4 × 7 × 3/8

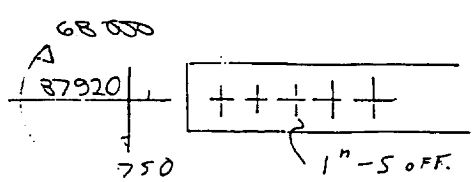
#1, 9, 10, 18 (TYPE 52)



P = 154,570
S = 240
M = 37,760

$P_{BOLT\,MAX}$ = 19830 ①.

R = 19830/29300 = .82

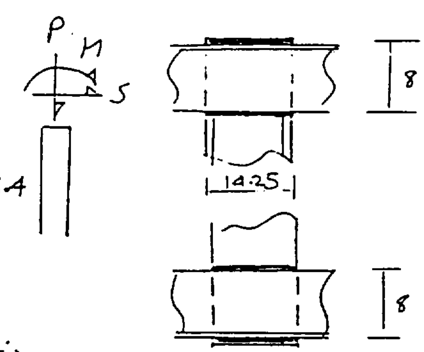


#3, 4, 6, 7, 12, 13, 15, 16, 19 – 30

$P_{BOLT\,MAX}$ = 18200 ②

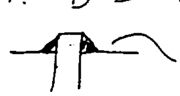
R = 18200/29300 = .75.

POSTS
#2, 5, 8, 11, 14, 17



P = 21220 L = 14.25
S_1 = 6660 aL = 538350/21220 = 25.4
M_1 = 538350 a = 25.4/14.25 = 1.8
  k = 5/14.25 = .56

AISC TABLE XIV, C = .256
P = C C_1 D L. ASSUME C_1 = 1.0.
D = P/C C_1 L = 21.2 / .256(14.25) = 5.8
FOR S_1 a = 0. C = 1.4. D = 6.7/1.4(14.25) = .34] 6.14

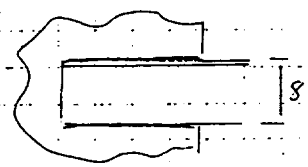
 2 × 5/16" R = .61

TRUSS 115 – 125 – JOINTS (CONT'D)

RECHECKING JOINTS AS WELDS:

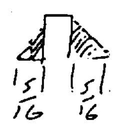
#1, 9, 10, 18.

P = 154,570
S = 240 = ~
M = 37,760
aL = M/P = .244
KL = 8



SAY L = 12":
a = .244/12 = .02
K = 8/12 = .67
C = 1.42 ASSUME C_1 = 1.0.

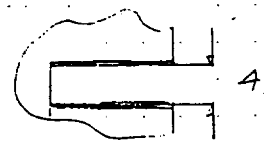
D = P/CC₁L = 154.6/1.42(12) = 9.07 =



FOR R = .91.

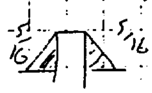
#3 .... #16;
#19 – #30.

P = 87,920
M = 68,000
S = 750



aL = 68000/87790 = .77

SAY L = 8
a = .77/8 = .096
K = 4/8 = .5
C = 1.52 ASSUME C_1 = 1.0.
D = 87.92/1.52(8) = 7.2
FOR S = 750, C = 1.37. D = .75/1.37(8) = .07
D = 7.3



R = .73

TRUSS 11S-12S - JOINTS (CONT'D)

BOLT LOADS (1)

A	B	C	D	E	F	G	H	I	J
FAST NO	X	Y	DIA	SUMD	SUMDX	SUMDY	SUMDX2	SUMDY2	F
1.0	0.0	0.0	1.0	8.0	36.0	12.0	252.0	36.0	18881.2
2.0	3.0	0.0	1.0						18824.6
3.0	6.0	0.0	1.0	XBAR	YBAR	J			18826.2
4.0	9.0	0.0	1.0	4.5	1.5	108.0			18886.2
5.0	0.0	3.0	1.0						19926.8
6.0	3.0	3.0	1.0	PX	PY	M			19873.1
7.0	6.0	3.0	1.0	154740.0	-240.0	-37760.0			19874.7
8.0	9.0	3.0	1.0						19931.5
9.0				PY/SD	PX/SD	M/J			0.0
10.0				-30.0	19342.5	-349.6			0.0
11.0									0.0
12.0									0.0
13.0									0.0
14.0									0.0
15.0									0.0
16.0									

BOLT LOADS (2)

A	B	C	D	E	F	G	H	I	J
FAST NO	X	Y	DIA	SUMD	SUMDX	SUMDY	SUMDX2	SUMDY2	F
1.0	0.0	0.0	1.0	5.0	30.0	0.0	270.0	0.0	18122.1
2.0	3.0	0.0	1.0						17710.9
3.0	6.0	0.0	1.0	XBAR	YBAR	J			17584.6
4.0	9.0	0.0	1.0	6.0	0.0	90.0			17749.3
5.0	12.0	0.0	1.0						18197.0
6.0				PX	PY	M			0.0
7.0				87920.0	-750.0	-68000.0			0.0
8.0									0.0
9.0				PY/SD	PX/SD	M/J			0.0
10.0				-150.0	17584.0	-755.6			0.0
11.0									0.0
12.0									0.0
13.0									0.0
14.0									0.0
15.0									0.0
16.0									

TRUSS 115-125

ELEMENT LOADS

MA ℄ MB ℄ S ℄ P

	A	B	C	D	E	F	G	H	I
1	1	0	34139	0	-11227	0	212	146657	14
2	2	0	13722	0	-125236	0	1120	-4766	-183
3	3	0	9273	0	-2004	0	82	31834	2
4	4	0	1929	0	-3625	0	42	-27454	-3
5	5	0	288837	0	-537410	0	6661	-18971	102
6	6	0	9902	0	-3912	0	106	64130	3
7	7	0	34746	0	-68003	0	750	-87920	-6
8	8	0	251355	0	-257129	0	4099	-1446	177
9	9	0	21267	0	4507	0	141	108066	-10
10	10	0	37758	0	-13000	0	237	154573	-18
11	11	0	-12829	0	-39357	0	279	-8460	87
12	12	0	9893	0	-2696	0	92	27506	-3
13	13	0	816	0	-1572	0	18	-22100	3
14	14	0	286459	0	-538353	0	6649	-21220	-74
15	15	0	9748	0	-3804	0	104	65031	-2
16	16	0	34299	0	-67190	0	741	-87717	7
17	17	0	255137	0	-266245	0	4203	-1296	-115
18	18	0	20112	0	4991	0	130	107614	14
19	19	-25697	0	16068	0	-250	0	-87751	-129
20	20	4431	0	-9719	0	97	0	-44410	8
21	21	-5046	0	6757	0	-82	0	-25910	-18
22	22	-1891	0	-9417	0	59	0	-82493	63
23	23	-10005	0	3878	0	-95	0	-55730	34
24	24	11409	0	-15970	0	164	0	-72185	-39
25	25	-2833	0	-1413	0	-13	0	-68656	-8
26	26	3986	0	-4389	0	58	0	-34143	11
27	28	11087	0	-5387	0	107	0	-26845	-15
28	29	-8566	0	23694	0	-274	0	50716	-1
29	30	-5013	0	10964	0	-104	0	-21749	16

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TRUSS 157-169 - JOINTS

ELEMENT TYPES USED ARE :

TYPE (59) $\rceil\lceil^{3}_{5}$ 5/16

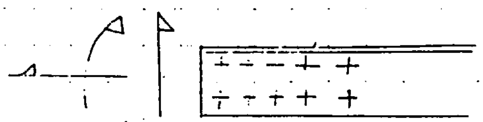
TYPE (52)	TYPE (53)	TYPE (55)	TYPE (57)	TYPE (65)	TYPE (67)	TYPE (68)
6, 8, 7/16	4, 7, 3/8	4, 6, 3/8	3 1/2, 5, 1/2	6, 8, 5/8	6, 8, 7/8	4, 7, 7/16

ELEMENTS #51, #60
(TYP (67))

$P = 277,750$
$S_1 = 430$
$M_1 = 63,000$

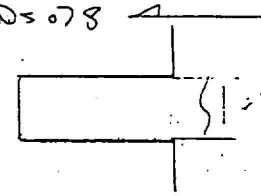
3/4" JOINT PLATE.
1" ϕ BOLT:
$P_{ALL} = 36,500$ LB.

10 BOLTS,
TAKE $M = 63000 + 10(430) = 67,300$



$P_{MAX\ BOLT} = 28350$ (1) $R = 28350/36500 = .78$

ALTERNATIVELY, AS WELDED JOINT :
SAY $L = 20''$

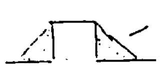


$KL = 8 \quad K = .4$
$aL = M/P = 66,010/277,750 = .24$
$a = .24/20 = .01 \qquad C = 1.51 \quad$ SAY $C_1 = 1.0$

$D = P/CC_1L = 277.8/1.51(20) = 9.2$

FOR 430 BEAM, $C = 1.31$. $D = .43/1.31(20) = .02$

$D = 9.4$

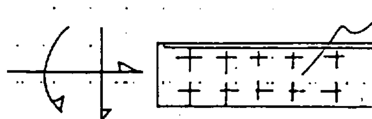


3/8", $Z = 9.4/12 = .78$.

ELEMENTS 56, 57, 59, 65, 66, 68-70, 72-75, 79

10 BOLTS

$P = 207,390$
$S_1 = 1360$
$M = 69,510$
TAKE $M_{CALC} = 69,510 + 1360(?)$
$= 81,750$.



1/2" JOINT PLATE;

$P_{BOLT\ MAX} = 20020$ (2)
$R = 21,500/24,300 = .88$.

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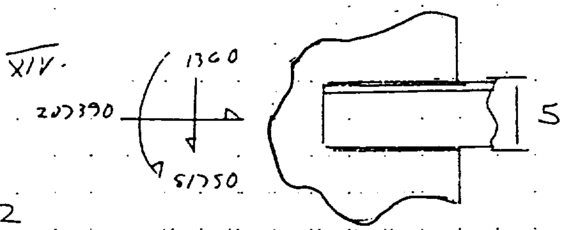
TRUSS 157-169 JOINTS - CONT'D

EL'S 56 ---- 75 CONT'D.

WELDED JOINT; A.I.S.C. TABLE XIV.



SAY L = 12",

KL = 5 K = 5/12 = .42

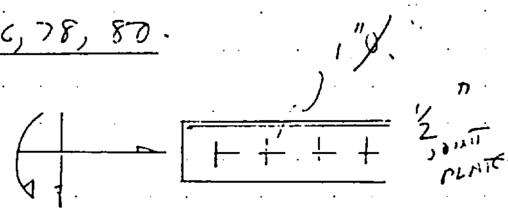
aL = M/P = 81750 / 207390 = .39
a = .39/12 = .03   C = 1.51   SAY C_1 = 1.0

D = P/CC,L = 207.4/1.51(12) = 11.4
FOR 1360 SHEAR, C = 1.31 D = 1.36/1.31(12) = .09] 11.5

FOR WELD $2 \times \frac{3}{8}$", R = 11.5/12 = .96
MAKE L 14 R ≐ .82

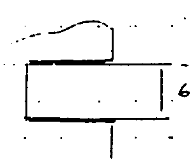
ELEMENTS 53, 54, 62, 63, 71, 76, 78, 80.

P = 89230
S = 250
M = 23880



TAKE M APPLIED = 23,880 + 7(250) = 25630
$P_{SHEAR\,MAX}$ = 22440 ⓑ R = 22440/24300 = .92

WELDED JOINT;



SAY L = 8"
KL = 6
K = .75
aL = M/P = 25630 / 89230 = .29
a = .29/6 = .048   C = 1.56   SAY C_1 = 1.0

D = P/CC,L = 89.2/1.56(8) = 7.1] 7.12
FOR S = 250, D = .25/1.5(8) = .02

FOR $2 \times \frac{5}{16}$", R = .71

4

ELEV 157-169 - JOINTS (CONT'D)

BOLT LOADS (1)

A	B	C	D	E	F	G	H	I	J
FAST NO	X	Y	DIA	SUMD	SUMDX	SUMDY	SUMDX2	SUMDY2	F
1.0	0.0	0.0	1.0	8.0	36.0	12.0	252.0	36.0	18490.7
2.0	3.0	0.0	1.0						18302.6
3.0	6.0	0.0	1.0	XBAR	YBAR	J			18297.2
4.0	9.0	0.0	1.0	4.5	1.5	108.0			18474.7
5.0	0.0	3.0	1.0						16680.6
6.0	3.0	3.0	1.0	PX	PY	M			16471.8
7.0	6.0	3.0	1.0	-138880.0	430.0	-66010.0			16465.8
8.0	9.0	3.0	1.0						16662.9
9.0				PY/SD	PX/SD	M/J			0.0
10.0				53.8	-17360.0	-611.2			0.0
11.0									0.0
12.0									0.0
13.0									0.0
14.0									0.0
15.0									0.0
16.0									

BOLT LOADS (2)

A	B	C	D	E	F	G	H	I	J
FAST NO	X	Y	DIA	SUMD	SUMDX	SUMDY	SUMDX2	SUMDY2	F
1.0	0.0	0.0	1.0	10.0	60.0	15.0	540.0	45.0	21497.3
2.0	3.0	0.0	1.0						21387.0
3.0	6.0	0.0	1.0	XBAR	YBAR	J			21345.0
4.0	9.0	0.0	1.0	6.0	1.5	202.5			21371.6
5.0	12.0	0.0	1.0						21466.6
6.0	0.0	3.0	1.0	PX	PY	M			20295.3
7.0	3.0	3.0	1.0	207390.0	-1360.0	81750.0			20178.5
8.0	6.0	3.0	1.0						20133.9
9.0	9.0	3.0	1.0	PY/SD	PX/SD	M/J			20162.1
10.0	12.0	3.0	1.0	-136.0	20739.0	403.7			20262.8
11.0									0.0
12.0									0.0
13.0									0.0
14.0									0.0
15.0									0.0
16.0									

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TRUSS 157-169 JOINTS - CONT'D

BOLT LOADS (3)

	A	B	C	D	E	F	G	H	I	J
	FAST NO	X	Y	DIA	SUMD	SUMDX	SUMDY	SUMDX2	SUMDY2	F
	1.0	0.0	0.0	1.0	4.0	18.0	0.0	126.0	0.0	22441.7
	2.0	3.0	0.0	1.0						22324.0
	3.0	6.0	0.0	1.0	XBAR	YBAR	J			22319.6
	4.0	9.0	0.0	1.0	4.5	0.0	45.0			22428.4
	5.0									0.0
	6.0				PX	PY	M			0.0
	7.0				89230.0	-250.0	23880.0			0.0
	8.0									0.0
	9.0				PY/SD	PX/SD	M/J			0.0
	10.0				-62.5	22307.5	530.7			0.0
	11.0									0.0
3	12.0									0.0
4	13.0									0.0
5	14.0									0.0
6	15.0									0.0
7	16.0									

RTIN MARIETTA
CHOUD OPERATIONS

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TRUSS 15)-16S ELEMENT LOADS

	Mn		Mb		S		P	
A	B	C	D	E	F	G	H	I
51	0	61856	0	53388	0	428	277746	166
52	0	-21336	0	55629	0	-522	-6826	-69
53	0	8419	0	-2498	0	72	87357	7
54	0	12363	0	-23319	0	248	-81430	-6
55	0	435699	0	-742698	0	8665	-26812	172
56	0	53878	0	-21774	0	526	138838	11
57	0	73726	0	-132549	0	1361	-171156	58
58	0	361833	0	-350371	0	5237	4783	227
59	0	25697	0	-14018	0	249	178898	-204
60	0	59843	0	63001	0	396	277589	-192
61	0	17740	0	48582	0	-403	-6234	82
62	0	8629	0	-2611	0	74	89234	-7
63	0	12644	0	-23877	0	254	-83049	6
64	0	443732	0	-755591	0	8819	-26157	-150
65	0	54594	0	-22080	0	533	141078	-7
66	0	73865	0	-133906	0	1370	-173941	-59
67	0	371385	0	-379820	0	5523	5484	-199
68	0	24912	0	-13114	0	239	179917	205
69	-21387	0	34019	0	-323	0	-207390	713
70	11137	0	-69173	0	511	0	-130390	-633
71	-5733	0	-268	0	-38	0	-74536	-15
72	20968	0	-48702	0	439	0	-170635	26
73	-69509	0	10593	0	-509	0	-131650	640
74	30651	0	-20047	0	296	0	-205855	-721
75	-47941	0	19596	0	-434	0	-173744	-26
76	1381	0	-5655	0	45	0	-73809	14
78	-4587	0	-1408	0	-19	0	-38401	-11
79	1524	0	-6349	0	60	0	127499	0
80	-1830	0	-1339	0	-3	0	-36713	12

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ALTERED ELEMENTS IN OUTER WALLS

TAKE REPLACEMENT END JOINTS AS TABLE T-528:

FOR 6 - 3/4 BOLTS & 3/8 SPLICE PLATE:

ELEMENTS	301
	306
	616
	912
	915

$P_{MAX} = 42170$
$S_{MAX} = 83$
$M_{MAX} = 11080$

$P_{BOLT\,MAX} = 7400$ lb (1)   3/4 ∅ D.S. = 13990 lb.
3/8 PLATE BRG = 13,700 LB.

R = 7400/13700 = .54

FOR 5 - 3/4 BOLTS & 3/8 SPLICE PLATE:

$P_{MAX} = 89133$
$S_{MAX} = 61$
$M_{MAX} = 6490$

ELEMENTS 619 & 625

$P_{BOLT\,MAX} = 17842$ lb (2)
NEED 1" BOLTS FOR BRG; 13700 × 1/.75 = 18270   R = 17940/18270 = .98.

1/2" PLATE; BRG = 18270 × .5/.375 = 24360.
R = 17940/24360 = .734

REMAINING 5 - 3/4" BOLTS IN 3/8 PLATE:

ELS. 501	926
701	1011
815	1014
921	1022

$P_{MAX} = 28200$
$S_{MAX} = 34$
$M_{MAX} = 4680$

$P_{BOLT\,MAX} = 5650$ lb (3)   R = 5650/13700 = .41

7 - 1" BOLTS IN 1/2" PLATE:

EL 901

$P_{MAX} = 50230$
S = 26
M = 4504

$P_{BOLT\,MAX} = 7250$ (4)   R = 7250/24360 = .3

ORIGINAL PAGE IS
OF POOR QUALITY

FORM MAF/MMA 35-016-04/74
NASA-MSFC-MAF

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ALTERED ELEMENTS IN OUTER WALLS (CONT'D)

9 - 1" BOLTS IN 1/2" PLATE

EL 621
622
623

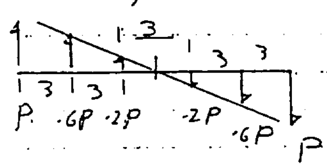
$P_{MAX} = 292900$
$S_{MAX} = 2227$
$M_{1MAX} = 202301$
$M_{2MAX} = 20170$

$P_{BOLT\,MAX} = 35310$ (5) 1" BOLT IN 1/2" PLATE $P_{ALL} = 29,300$ LB.

SAY 12 - 1" BOLTS IN 5/8" PLATE. $P_{ALL\,D.S.} = 39,560$ LB.
$P_{ALL\,BRG} = 30,400$ LB

$P_{MAX\,BOLT} = 28850$ (6) $R = 28850/30,400 = .95$

M2 ON



$2\,0170 = 4\,(7.5P + 4.5(.6P) + 1.5(.2P)) = 42\,P \quad P = 480$ = NEGLIGIBLE

$R = .95$

9 - 1" BOLTS IN 1/2" PLATE. $\boxed{EL\ 906}$

$P_{MAX} = 50150.$ $P_{BOLT\,MAX} = 5790$ (7)
$S_{MAX} = 179.$
$M_{MAX} = 19140.$ O.K.

I.E. FOLLOW TABLE T-S29 FOR JOINT SIZES
EXCEPT ELEMENTS 619
625
621
622
623.

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NASA-MSFC-MAF

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ALTERED ELEMENTS IN OUTER WALLS -(CONT'D)

BOLT LOADS (1)

A	B	C	D	E	F	G	H	I	J
FAST NO	X	Y	DIA	SUMD	SUMDX	SUMDY	SUMDX2	SUMDY2	F
1.0	0.0	0.0	1.0	6.0	18.0	9.0	90.0	27.0	7393.4
2.0	3.0	0.0	1.0						7364.1
3.0	6.0	0.0	1.0	XBAR	YBAR	J			7395.9
4.0	0.0	3.0	1.0	3.0	1.5	49.5			6724.8
5.0	3.0	3.0	1.0						6692.6
6.0	6.0	3.0	1.0	PX	PY	M			6727.6
7.0				42170.0	83.0	11080.0			0.0
8.0									0.0
9.0				PY/SD	PX/SD	M/J			0.0
10.0				13.8	7028.3	223.8			0.0
11.0									0.0
12.0									0.0
13.0									0.0
14.0									0.0
15.0									0.0
16.0									

BOLT LOADS (2)

A	B	C	D	E	F	G	H	I	J
FAST NO	X	Y	DIA	SUMD	SUMDX	SUMDY	SUMDX2	SUMDY2	F
1.0	0.0	0.0	1.0	5.0	30.0	0.0	270.0	0.0	17841.6
2.0	3.0	0.0	1.0						17837.8
3.0	6.0	0.0	1.0	XBAR	YBAR	J			17836.6
4.0	9.0	0.0	1.0	6.0	0.0	90.0			17838.1
5.0	12.0	0.0	1.0						17842.1
6.0				PX	PY	M			0.0
7.0				89183.0	61.0	6490.0			0.0
8.0									0.0
9.0				PY/SD	PX/SD	M/J			0.0
10.0				12.2	17836.6	72.1			0.0
11.0									0.0
12.0									0.0
13.0									0.0
14.0									0.0
15.0									0.0
16.0									

ALTERED ELEMENTS IN OUTER WALLS -(CONT'D)

BOLT LOADS -(3)

(3)	A	B	C	D	E	F	G	H	I	J
1	FAST NO	X	Y	DIA	SUMD	SUMDX	SUMDY	SUMDX2	SUMDY2	F
2	1.0	0.0	0.0	1.0	5.0	30.0	0.0	270.0	0.0	5648.3
3	2.0	3.0	0.0	1.0						5642.0
4	3.0	6.0	0.0	1.0	XBAR	YBAR	J			5640.0
5	4.0	9.0	0.0	1.0	6.0	0.0	90.0			5642.3
6	5.0	12.0	0.0	1.0						5649.0
7	6.0				PX	PY	M			0.0
8	7.0				28200.0	34.0	4680.0			0.0
9	8.0									0.0
10	9.0				PY/SD	PX/SD	M/J			0.0
11	10.0				6.8	5640.0	52.0			0.0
2	11.0									0.0
13	12.0									0.0
14	13.0									0.0
15	14.0									0.0
16	15.0									0.0
17	16.0									

BOLT LOADS -(4)

(4)	A	B	C	D	E	F	G	H	I	J
1	FAST NO	X	Y	DIA	SUMD	SUMDX	SUMDY	SUMDX2	SUMDY2	F
2	1.0	0.0	0.0	1.0	7.0	27.0	9.0	171.0	27.0	7249.1
3	2.0	3.0	0.0	1.0						7246.2
4	3.0	6.0	0.0	1.0	XBAR	YBAR	J			7247.1
5	4.0	9.0	0.0	1.0	3.9	1.3	82.3			7251.7
6	5.0	0.0	3.0	1.0						7084.9
7	6.0	3.0	3.0	1.0	PX	PY	M			7082.0
8	7.0	6.0	3.0	1.0	50230.0	26.0	4504.0			7082.9
9	8.0									0.0
10	9.0				PY/SD	PX/SD	M/J			0.0
11	10.0				3.7	7175.7	54.7			0.0
2	11.0									0.0
3	12.0									0.0
14	13.0									0.0
15	14.0									0.0
16	15.0									0.0
17	16.0									

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ALTERED ELEMENTS IN OUTER WALLS (CONT'D)

BOLT LOADS - (5)

A	B	C	D	E	F	G	H	I	J
FAST NO	X	Y	DIA	SUMD	SUMDX	SUMDY	SUMDX2	SUMDY2	F
1.0	0.0	0.0	1.0	9.0	48.0	12.0	396.0	36.0	34841.2
2.0	3.0	0.0	1.0						34336.8
3.0	6.0	0.0	1.0	XBAR	YBAR	J			34247.6
4.0	9.0	0.0	1.0	5.3	1.3	160.0			34576.9
5.0	12.0	0.0	1.0						35312.8
6.0	0.0	3.0	1.0	PX	PY	M			31122.6
7.0	3.0	3.0	1.0	292900.0	2227.0	202301.0			30556.9
8.0	6.0	3.0	1.0						30456.7
9.0	9.0	3.0	1.0	PY/SD	PX/SD	M/J			30826.4
10.0				247.4	32544.4	1264.4			0.0
11.0									0.0
12.0									0.0
13.0									0.0
14.0									0.0
15.0									0.0
16.0									

BOLT LOADS - (6)

A	B	C	D	E	F	G	H	I	J
FAST NO	X	Y	DIA	SUMD	SUMDX	SUMDY	SUMDX2	SUMDY2	F
1.0	0.0	0.0	1.0	12.0	90.0	18.0	990.0	54.0	25650.3
2.0	3.0	0.0	1.0						25416.5
3.0	6.0	0.0	1.0	XBAR	YBAR	J			25305.3
4.0	9.0	0.0	1.0	7.5	1.5	342.0			25318.4
5.0	12.0	0.0	1.0						25455.4
6.0	15.0	0.0	1.0	PX	PY	M			25714.4
7.0	0.0	3.0	1.0	292900.0	2227.0	202301.0			23902.1
8.0	3.0	3.0	1.0						23651.0
9.0	6.0	3.0	1.0	PY/SD	PX/SD	M/J			23531.5
10.0	9.0	3.0	1.0	185.6	24408.3	591.5			23545.5
11.0	12.0	3.0	1.0						23692.8
12.0	15.0	3.0	1.0						28853.3
13.0									0.0
14.0									0.0
15.0									0.0
16.0									

ARTIN MARIETTA
CHOUD OPERATIONS

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LTERED ELEMENTS IN OUTER WALLS (CONT'D)

BOLT LOADS (7)

)	A	B	C	D	E	F	G	H	I	J
	FAST NO	X	Y	DIA	SUMD	SUMDX	SUMDY	SUMDX2	SUMDY2	F
	1.0	0.0	0.0	1.0	9.0	48.0	12.0	396.0	36.0	5765.0
	2.0	3.0	0.0	1.0						5737.6
	3.0	6.0	0.0	1.0	XBAR	YBAR	J			5732.6
	4.0	9.0	0.0	1.0	5.3	1.3	160.0			5750.0
	5.0	12.0	0.0	1.0						5789.6
	6.0	0.0	3.0	1.0	PX	PY	M			5408.3
	7.0	3.0	3.0	1.0	50150.0	174.0	19140.0			5379.1
	8.0	6.0	3.0	1.0						5373.8
0	9.0	9.0	3.0	1.0	PY/SD	PX/SD	M/J			5392.3
	10.0				19.3	5572.2	119.6			0.0
	11.0									0.0
3	12.0									0.0
4	13.0									0.0
5	14.0									0.0
6	15.0									0.0
7	16.0									

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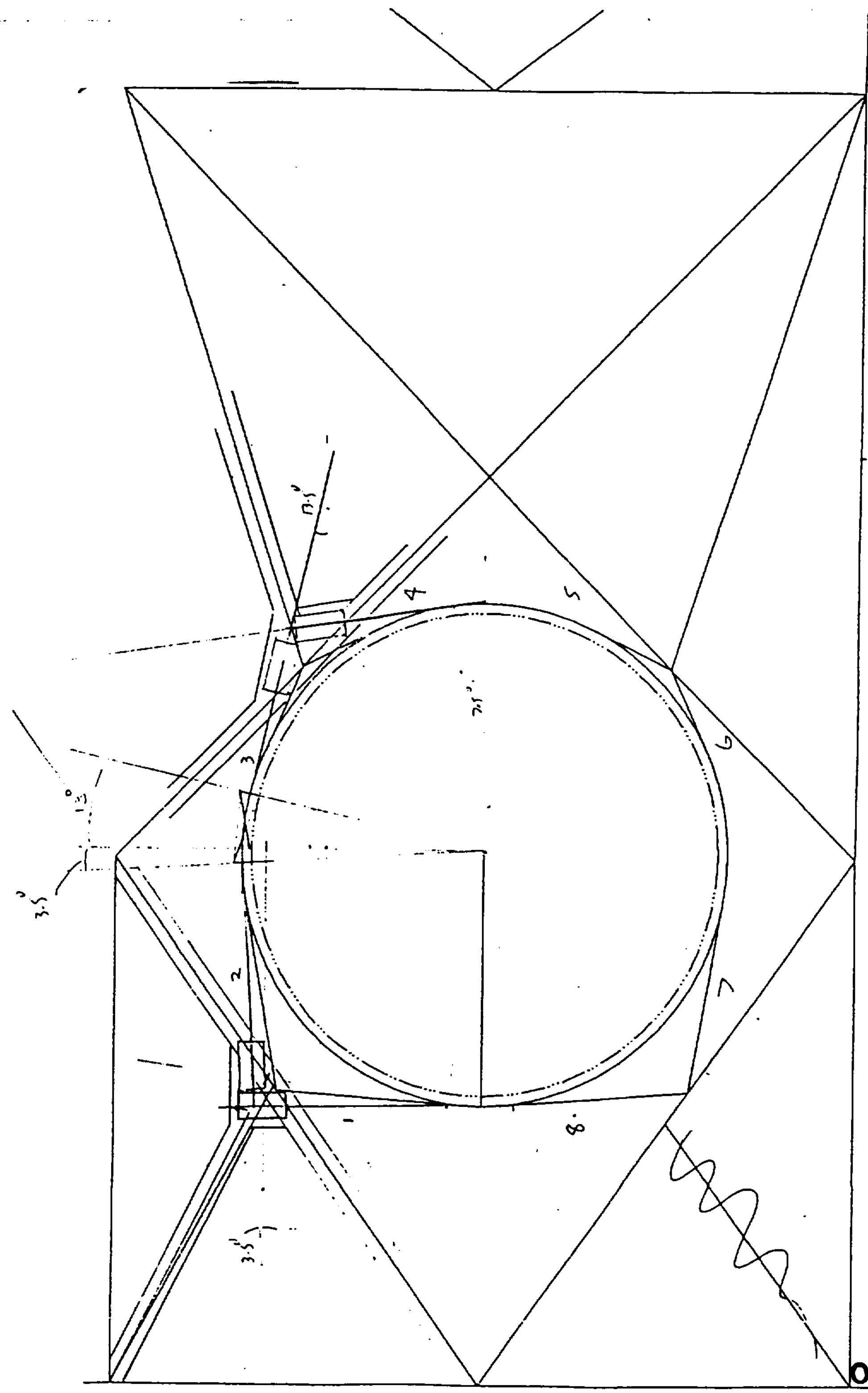
ALTERED ELEMENTS IN OUTER WALLS (CONT'D)

ELEMENT LOADS & JOINT DETAILS

	A	B	C	D	E	F	G	H	I	J	K	L	M
1					VERTICALS								
2	ELEMENT	MA1	MA2	MB1	MB2	S1	S2	P	T	EL TYPE	NO. OF BOLTS	SIZE	PLATE T
3	301	0	5146	0	-9704	0	65	-38287	3	55	6	0.75	0.375
4	306	0	-11082	0	8005	0	-83	-42166	-2	55	6	0.75	0.375
5	501	0	2103	0	-2471	0	19	-15603	-2	59	5	0.75	0.375
6	616	0	-2788	0	3529	0	-19	-32988	-2	55	6	0.75	0.375
7	619	0	-6205	0	6500	0	-61	84744	-1	59	5	0.75	0.375
8	621	0	-79225	0	32055	0	-631	-248157	-131	50	9	1.00	0.5
9	622	101250	-21301	-202301	-20167	2227	-298	292907	-9	50	9	1.00	0.5
10	623	0	37090	0	-85119	0	675	-238844	102	50	9	1.30	0.5
11	625	-0	6486	0	-6148	0	60	89183	-1	59	5	0.75	0.375
12	701	0	2841	0	-4675	0	32	-27897	-4	57	5	0.75	0.375
13	815	0	-2256	0	601	0	-12	25443	3	57	5	0.75	0.375
14	901	0	1747	0	-4504	0	26	-50233	61	54	7	1.00	0.5
15	906	-2	17352	0	19144	0	-174	-50152	-117	51	9	1.00	0.5
16	912	0	2339	0	-4348	0	28	-24509	-3	55	6	0.75	0.375
17	915	0	-3616	0	1768	0	-23	-26166	2	55	6	0.75	0.375
18	921	0	2211	0	-2419	0	21	-28443	2	58	5	0.75	0.375
19	926	0	3851	0	-3450	0	34	-28196	4	57	5	0.75	0.375
20	1011	0	282	0	-1260	0	7	21212	2	59	5	0.75	0.375
21	1014	0	2141	0	-2623	0	20	24234	-2	58	5	0.75	0.375
22	1022	0	1135	0	-604	0	8	26030	0	59	5	0.75	0.375

ELEV 214 - STAY RODS & BRACKETS

GEOMETRY



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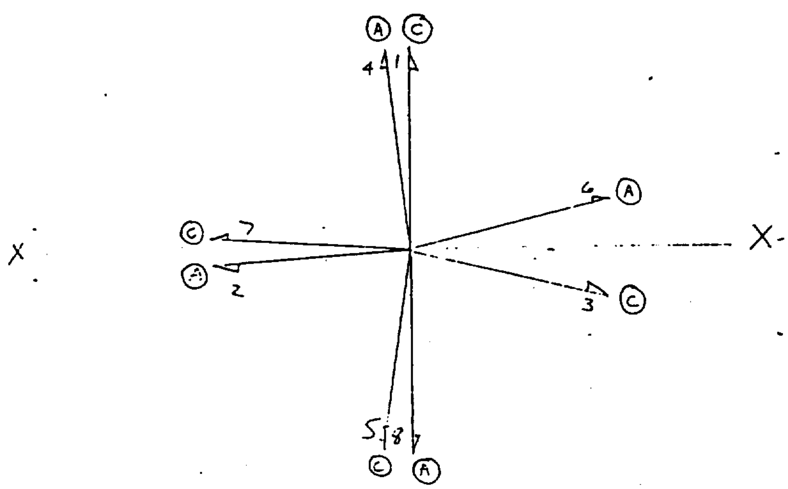
ELEV 214 - STAY RODS & BKTS

LOAD VECTORS

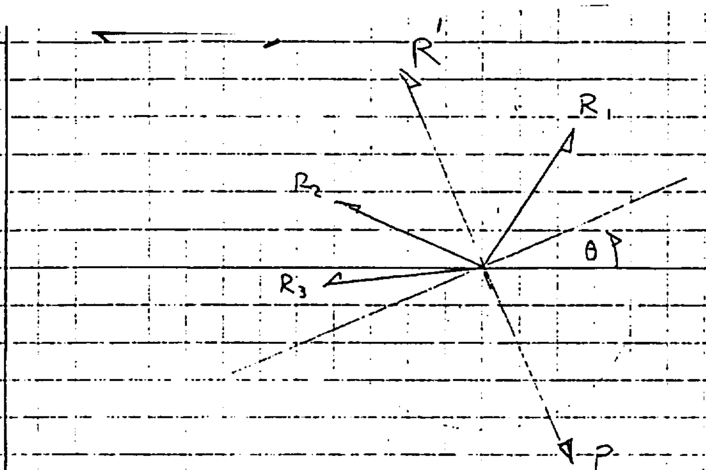


FROM SKETCH, RESTRAINING FORCE DIRECTIONS CAN BE LAID OUT AS ABOVE.

NOTE: RODS TAKEN AS BEARING TENSION LOADS ONLY.

ELEV 214 - STAY RODS & BKTS

LOAD VECTORS - CONT'D



SAY SEISMIC LOAD VECTOR = P, BALANCING VECTOR = R'.
P CAN HAVE ANY ANGULAR POSITION.
EXAMINATION OF THE BALANCING LOAD DIAGRAM SHOWS THAT AS P' [1] ROTATES, AVAILABLE BALANCE LOADS ARE EITHER 3 OR 4 IN NUMBER.
LABEL R's CAUSING CLOCKWISE MOMENT AS (C)
" " A/CLOCKWISE " " (A)

EQUATIONS ARE:
$$\Sigma\left(R\cos(\theta R_N - \theta R')\right) = R' \quad — (1)$$
$$\Sigma\left(R\sin(\theta R_N - \theta R')\right) = 0. \quad — (2)$$
$$\Sigma R_C + \Sigma R_A = 0. \quad — (3)$$

THE POSITIONS GIVING 4 BALANCING LOADS ARE REDUNDANT SOLUTIONS.

CHECK VARIOUS CASES WITH 3 BALANCE LOADS.

TAKING XX AS BASE, θ VALUES ARE:

VECTOR	θ°	TYPE
6	13.5	A
1	90	C
4	97.5	A
7	176.5	C
2	183.5	A
5	262.5	C
8	270	A
3	346.5	C

AVAILABLE VECTORS LIE BETWEEN $\theta_{R'} + 90$ & $\theta R' - 90$

[1] EXCEPT WHEN $\theta R' = 0°$, WHEN R_3 & R_6 GIVE BALANCE.

ELEV 214 – STAY RODS & BRACKETS

UNIT LOAD SOL'NS

CONSIDER R' ROTATING ROUND DIAGRAM

$\theta_{R'}$	AVAILABLE BALANCE VECTORS 1	2	3	4	5	6	7	8	3 OR LESS
0			✓			✓			✓
0–7.5	✓		✓			✓			✓
7.5–76.5	✓		✓	✓		✓			
76.5–86.5	✓			✓		✓			✓
86.5–93.5	✓			✓		✓	✓		
93.5–103.5	✓	✓		✓		✓	✓		
103.5–172.5	✓	✓		✓			✓		
172.5–180	✓	✓		✓	✓		✓		SYMMETRICAL.
180–187.5		✓		✓	✓		✓	✓	
187.5–									

FOR $\theta R' = 0$, $R_3 = R_6 = P/2\cos 13.5 = .514P$.

FOR 3 VECTOR CASES,
IF THE 3 VECTORS ARE DENOTED x, y & z;
SINCE (A) & (C) VECTORS ALTERNATE ROUND DIAGRAM, EQUATIONS ARE :

$$x\cos\theta_x + y\cos\theta_y + z\cos\theta_z = 1 \quad \text{FOR UNIT } R'$$
$$x\sin\theta_x + y\sin\theta_y + z\sin\theta_z = 0$$
$$x - y + z = 0 \quad \text{FOR 0 TORQUE ON TANK.}$$

TAKE EACH CASE AT EITHER END & MID-PT OF RANGE; I.E.

$\theta R'$	x	y	z	θ_x	θ_y	θ_z	EQUATION SOLUTIONS R_x	R_y	R_z	
0	R_1	R_3	R_6	−90	13.5	−13.5	0	.514	.514	AS ABOVE
3.75	"	"	"	−86.25	17.25	−9.75	.0853	.5558	.4704	
7.5	"	"	"	−82.5	21.0	−6.0	.1703	.5950	.4246	
76.5	R_1	R_4	R_6	−13.5	−21	63.	.2900	.612	.322	
81.5	"	"	"	−8.5	−16	68	.3548	.5859	.2305	
86.5	"	"	"	−3.5	−11	73	.4169	.5540	.1371	

J.C. DATE 3/30 SUBJECT PFBTS.

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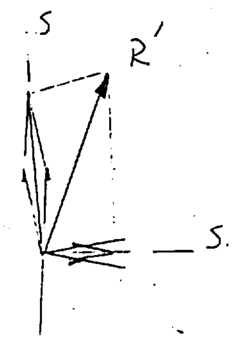
ELEV 214 – STAY RODS & BKTS

ELEV 147

UNIT LOADS – CONT'D



FOR A 4 VECTOR CASE, ANY R' IN SECTOR SS CAN BE TAKEN AS SHOWN, WITH THE MAXIMUM ON ANY MEMBER GIVEN BY $.514R'$, (I.E. COND $\theta \cdot R' = 0$)

FROM PREVIOUS TABLE TAKE MAX ROD LOAD $= .612P$.

$P = 104$ KIPS $R = .612(104) = 63.6^K$.

TAKE $F_{ALL} = 22(1.33) = 29$ KSI, SINCE LOADING IS SEISMIC.

A_{MIN} FOR ROD $= 63.6/29 = 2.19$ in²

I.E. MIN EFFECTIVE (THREAD ROOT) DIA = 1.67.

AT EL 147, $P_{SEISMIC} = 19$ KIPS

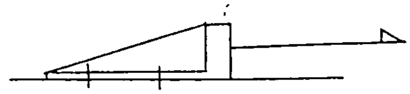
MIN EFF DIA REQUIRED $= 1.67\left(\frac{19}{104}\right)^{1/2} = .71$ SAY 1" DIA RODS

ELEV 214 - STAY RODS & BKTS

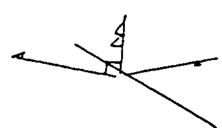
SUPPORT BEAM LOADS

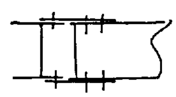
FROM FOREGOING;

1) MAX ROD LOAD = 63.6^K
2) REMAINING BALANCE LOADS OCCUR AT OTHER SUPPORT POINTS
3) ASSUME THE SAME MAX LOAD OCCURRING AT ANY OF THE 4 STAY POINTS FROM EITHER OF THE RODS ATTACHING TO THE POINT

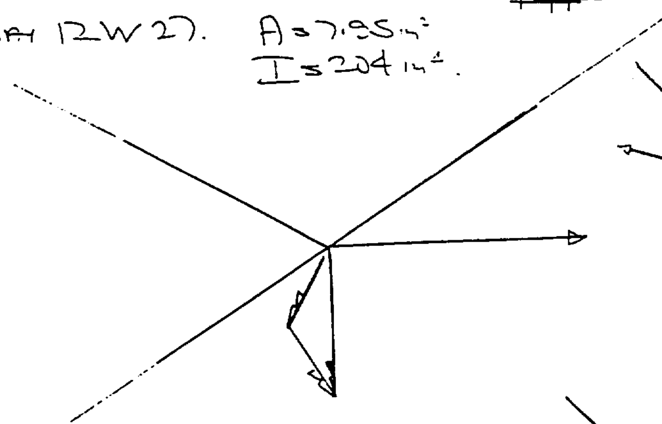


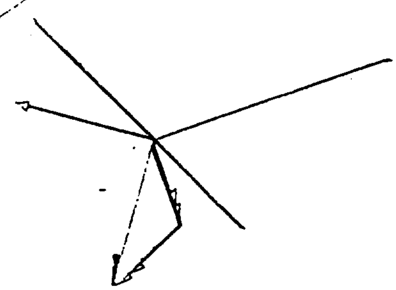
FOR ROD ATTACHMENT SAY 4" ABOVE TOP FACE OF STAYS, SUBSTANTIAL MOMENT WILL BE INDUCED ON MEMBERS.
THIS CAN BEST BE MET BY USING I-BEAMS WITH FLANGE CONNECTIONS

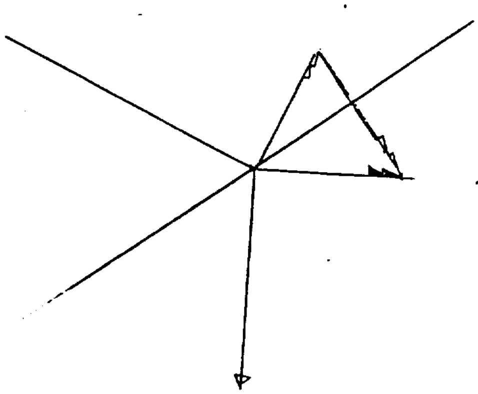


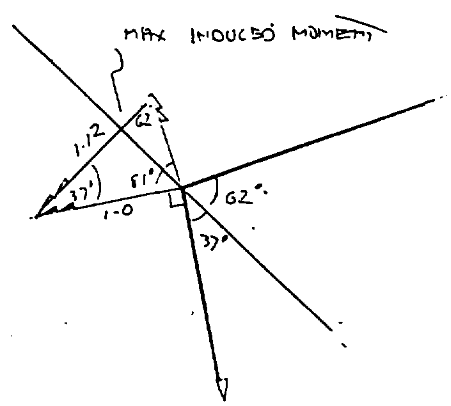


SAY 12W27. A = 7.95 in^2
I = 204 in^4.









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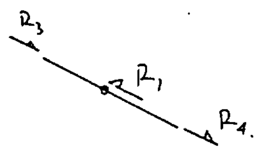
EL 214 - STAY RODS & BKTS

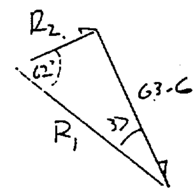
SUPPORT BEAM LDS - CONT'D

12W27, d = 11.96. M = 1.12(63.6)(11.96/2 + 4) = 710.9 IN-K.

SIMILARLY, R_1 = 1.12(63.6) = 71.2 K.

ALLOWING R_1 DISTRIBUTION TO R_3 & R_4 TO BE BETWEEN 70/30 & 30/70;



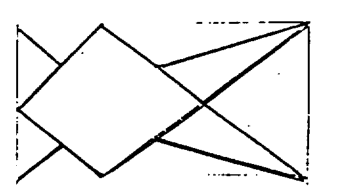


P = .7(71.2) = 49.8 K

BEAM f_{DIRECT} = 49.8/7.95 = 6.26 KSI.
f_b = 710.9(5.98)/204 = 20.8 KSI.

6.26/1.33(22) = .214
20.8/1.33(24) = .652 R_{MS} ≐ .87

I.E. HAVE MEMBERS SHOWN 12W27.
(EL 214).



USING A SIMILAR APPROACH AS EL 147;
SEISMIC TANK LOAD = 19 KIPS.

RATIOING FROM EL 214 RESULTS,
SAY 6B16

A = 4.72 IN²
I = 31.7 IN⁴
d = 6.25 IN.

$P_{ROD\ MAX}$ = .612(19) = 11.6 KIPS.
ASSUMING 3" LOAD OFFSET ABOVE BEAM FLANGE.
M_{MAX} APPLIED TO STAY JOINT = 11.6(3 + 3.125) = 71.1 IN-K.

f_{DIRECT} = 11.6(1.12)/4.72 = 2.75 KSI
f_b = 71.1(3.125)/31.7 = 7.0 KSI.

f_{MS} = 9.75 KSI
R.S. < 1.0.

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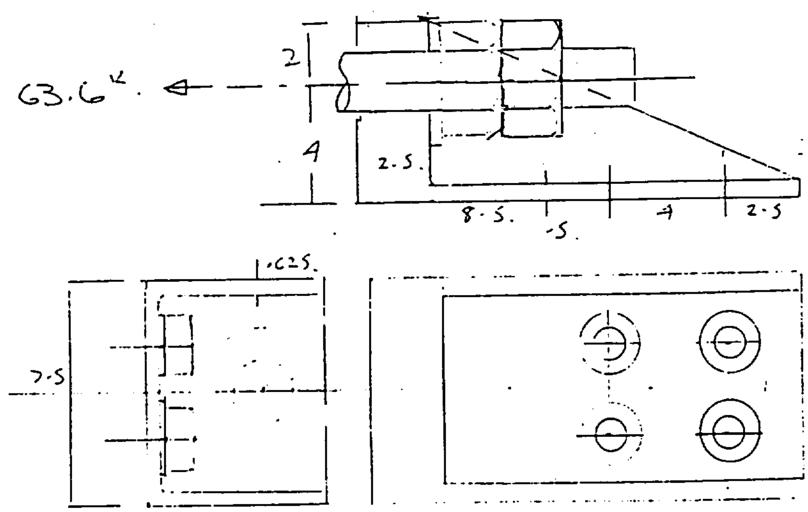
ELEV 214 - STAY BRACKETS

FOR STAY ROD FITTINGS;

EL 214.

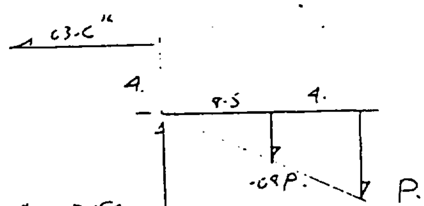
$P_{ROD} = 63.6^k$.



BRACKET DIMENSIONS ASSUMED AS ABOVE

$63.6(4) = P(12.5) + .65P(8.5)$

$P = 13.9k$.



1" BOLTS. $T_{ALL} = 31.4^k$.
$S_{ALL} = 17.26^k$.

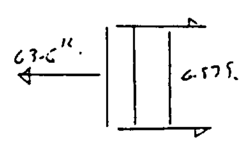
$P_T = 13.9/2 = 6.85^k$. $R_T = 6.85/31.4 = .218$

$P_S = 63.6/4 = 15.9^k$. $R_S = 15.9/17.26 = .921$.

$R_{NET} = (.921^2 + .218^2)^{1/2} = .95$.

PAD

TAKE AS SHOWN. $M = 63.6(6.875)/4$
$= 109.3$ IN-K.



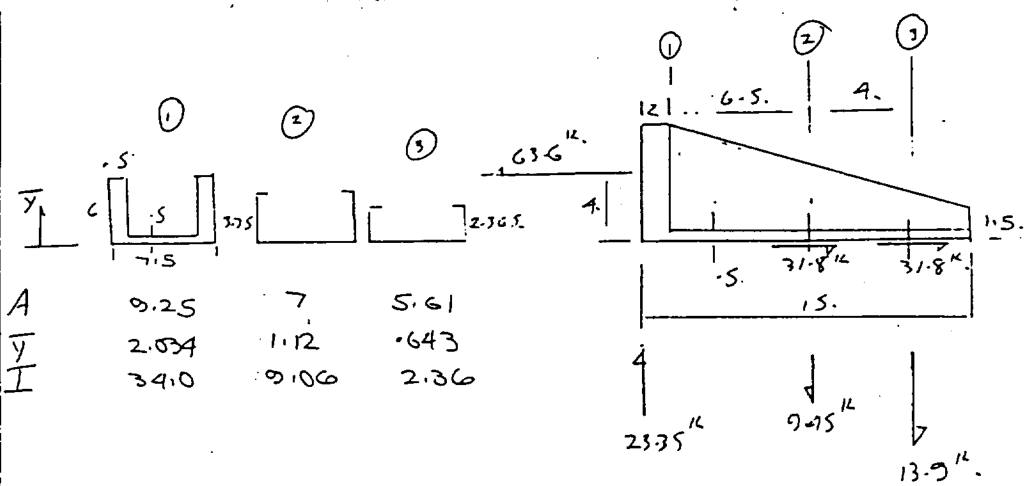
$Z = 6.875(2.5)^2/6 = 7.16$.

$F_b = 109.3/7.16 = 15.3$ KSI.

SAY 2" THICK, $Z = 4.58$. $F_b = 23.9$ KSI. $R = 23.9/24(1.31) = .75$

$F_S = 63.6/2(2)6.875 = 2.31$ KSI.

ELEV 214 - STAY BRACKETS (CONT'D)



	①	②	③
A	9.25	7	5.61
$\bar{y}$	2.034	1.12	.643
I	34.0	9.06	2.36

1) $f_C = 63.6/9.25 = 6.88$ ksi.
$M = 63.6(4-2.03) = 125.3$ in-k.
$f_b = 125.3(6-2.03)/34.0 = 14.6$ ksi. $f_{NET} = 21.5$ ksi.

2) $M_{LEFT} = 63.6(4-1.12) - 23.35(6.5) = 31.4$ in-k
$M_{RIGHT} = 31.4 + 31.8(1.12) = 67.0$ in-k

$f_{C\,LEFT} = 63.6/7.0 = 9.09$ ksi.
$f_{b\,LEFT} = 31.4(3.75-1.12)/9.06 = 9.1$ ksi. $f_{NET} = 18.2$ ksi

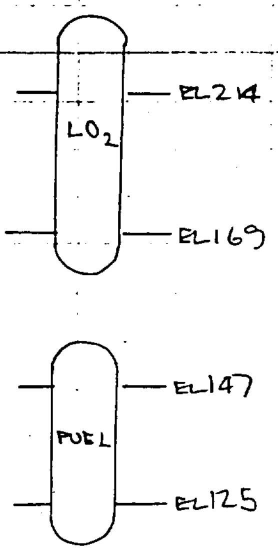
$f_{C\,RIGHT} = 31.8/7.0 = 4.5$ ksi
$f_{b\,RIGHT} = 67.0(3.75-1.12)/9.06 = 19.4$ ksi $f_{NET} = 23.9$ ksi.

3) $M = 31.8(.643) = 20.4$ in-k.
$f_C = 31.8/5.61 = 5.7$ ksi.
$f_b = 20.4(2.365-.643)/2.36 = 14.9$ ksi, $f_{NET} = 20.6$ ksi.

$R \doteq 23.9/1.33(22) = .82$

ELEV 214 – STAY RODS (CONT'D)

CONSIDERING POSSIBLE VERTICAL TANK DEFLECTIONS RELATIVE TO STAND,



THERMAL

INNER TANKS ARE INSULATED, HOWEVER ALLOW FOR 50°F TEMP. DIFFERENCE BETWEEN OUTER TANKS & STAND.

α STRUCTURAL STEEL = .000 0065
α STAINLESS STEEL = .000 0096

FOR LO2 TANK BETWEEN EL214 & EL169.

$\Delta T = 50(540)(.0000096 - .0000065) = \underline{.08''}$

STRUCTURAL

TAKE TRUSS AS BEAM 468" LONG BY 120" DEEP STRESSED TO 20 KSI.

$R = Ec/f = 29.5\times10^6 \times 60 / 20{,}000 = 88{,}500$ IN.

$\theta = \sin^{-1}\left(\frac{468}{2\times 88500}\right) = .0028$ RAD $= .16°$.

$\Delta = R(1-\cos\theta) = 88500(1-\cos .16°) = \underline{.35''}$

FOR LOWER TANK, ASSUME SURROUNDING STRUCTURE STRESSED TO 10 KSI AVERAGE BY LO2 TANK WT.

$\Delta = 10{,}000(.264)/29.5\times10^6 = \underline{.09''}$

I.E. DEFLECTIONS SMALL ENOUGH TO BE TAKEN CARE OF BY STAY ROD SYSTEM.

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APPROVED ____ DATE ____ REV ____ DATE ____

PAIRED ELEMENTS

THE STRESS PROGRAM TREATS EACH ELEMENT INDIVIDUALLY, I.E. IT DOES NOT ALLOW FOR THE FACT THAT 2 CO-JOINT ELEMENTS MAY HAVE A COLUMN LENGTH IN A GIVEN PLANE EQUAL TO THE SUM OF THE ELEMENT LENGTHS IF THERE IS NO STAY MEMBER AT THE COMMON NODE GIVING A SUPPORT IN THE PLANE.

THIS SECTION CONTAINS A HAND CHECK OF AFFECTED MEMBERS. IT CHECKS THAT THE EULER STRESS (AS A PIN-ENDED MEMBER) $>> f_{AVERAGE}$.

ARTIN MARIETTA
ICHOUD OPERATIONS

SHEET ____ OF 25-2

JC DATE 3/30 SUBJECT PFBTS.

WORK PACKAGE

.JVED DATE

ROVED DATE REV DATE

PAIRED ELEMENTS - MEMBER LOADS

	A	B	C	D	E	F	G	H	I
1	ELEMENTS	MA1	MA2	MB1	MB2	S1	S2	P	T
2	154	-14393	3658	23742	1713	-296	24	41041	-12
3	155	26615	4690	-19574	5337	270	14	-46470	-12
4	157	100400	5405	-67687	0	1697	55	661	15
5	158	211603	10718	-187295	5258	4029	55	109738	11
6	170	100299	-5906	-67073	0	1690	-60	679	-11
7	171	212839	-11728	-188297	-5762	4052	-60	109701	-5
8	176	-16168	-3846	25587	-1780	-324	-26	41079	14
9	177	26306	-4795	-19429	-5496	267	-15	47053	11
10	266	-131963	-11644	-37632	4617	-1626	-280	-55858	-63
11	267	461017	-11391	-210259	-11649	16373	-536	-110176	-65
12	268	47830	-17159	-72845	-27679	2943	753	-122278	-154
13	269	69846	9373	35479	-17160	627	450	-140993	-156
14	271	379478	-18905	-365921	-38130	7529	407	-36801	57
15	281	-367021	-38130	373794	-19003	-7482	406	-34265	-63
16	291	-130945	-11457	-40717	-7094	-1583	314	-55667	64
17	292	454913	11578	-209109	-11460	16196	562	-109910	65
18	293	68042	18500	-101867	31475	4144	-810	-122470	152
19	294	59589	-11022	56239	18501	146	-500	-140218	154
20	354	-10596	-14577	18338	-16855	-193	23	47947	26
21	355	23697	-18659	-14329	-16992	254	21	-40693	56
22	357	-11445	14425	19515	17062	-206	-27	47408	-26
23	358	23029	17861	-13822	16648	246	-25	42242	-55
24	454	-15331	-51043	-26499	-44758	113	668	37620	121
25	455	92270	-41367	-43285	-51020	863	-586	-48755	-122
26	465	1071060	-32734	-1322950	-46915	20591	-696	152256	-219
27	475	-1321060	-46916	1040610	31966	-20478	-692	151426	231
28	495	-12636	51132	-27825	46882	120	-683	-39557	-9
29	496	89738	-42815	-41300	51117	831	-598	-48200	26
30	554	-12154	-11906	14295	-8832	-185	85	41276	-60
31	555	13622	2901	-12167	-9289	164	74	-38328	-49
32	556	210542	-5369	-182554	0	4736	-65	1725	-186
33	577	282223	-12710	-244381	-5336	4619	-65	177139	-222
34	568	212845	-5371	-185172	0	4795	-65	1668	227
35	578	287295	-12491	-249806	-5114	4711	-65	179050	267
36	572	-12929	12494	14863	9055	-194	-80	41790	57
37	573	12323	-2745	-11312	8400	151	-68	-37513	48
38	666	-141488	25905	-72892	14575	-1182	-589	-81198	-712
39	667	599466	-27919	-325635	25964	19671	-1146	-197381	-714
40	668	74845	-30268	-155687	-68287	4905	1821	-217238	-1502
41	669	204654	54448	43089	-30267	2485	1264	-276796	-1506
42	671	262458	-35936	-223218	-60461	4260	807	-35418	27
43	681	-222394	-60461	262989	-36472	-4258	807	-34250	-24
44	692	-144606	-27707	-70315	-18139	-1290	630	-81126	672
45	693	608379	25890	-330670	-27763	19977	1142	-199210	672
46	694	77410	30607	-161473	69644	5083	-1821	-219014	1516
47	695	207982	-58740	44888	30607	2493	-1334	-279902	1520

ARTIN MARIETTA
ICHOUD OPERATIONS

SHEET ____ OF 26-1.

JC DATE 3/30 SUBJECT PFBTS.

WORK PACKAGE

ROVED ____ DATE ____

ROVED ____ DATE ____ REV ____ DATE ____

TANK MAIN SUPPORT CONNECTIONS

HOLD-DOWN BOLTS AT ELEV 169 & ELEV 125
TAKE HORIZONTAL SHEAR LOADS ONLY.

REF LOADING SUMMARY.

TOTAL SIDE LOADS (KIPS)		
ELEV.	WIND	SEISMIC
125	17.4	19
169	13.6	28.

FOR 4 SUPPORTS / TANK
4 - 3/4" BOLTS / SUPPORT.

28/16 = 1.75 K. R.S = 1.75/9.7 = .18 <

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OF POOR QUALITY

M MAF/MMA 35-016-04/74
A-MSFC-MAF